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FUEL PROBLEMS IN BRITAIN

THE debate on the fuel and power industries in the House of Commons on October 26 was perhaps the first occasion on which the fuel industries of Britain have been discussed with objectivity, and without nationalization being raised as a matter for party political dispute. Most speakers made a real effort to look at the three corporations concerned objectively and from the point of view of national rather than sectional interests. There was naturally some complaint that the time was too short for adequate discussion of the annual reports and accounts concerned, but that could have been an advantage had it stirred those participating to discuss the larger question of a national policy and the interrelationships of the three corporations, rather than their operation as independent units. None the less, the trend of the debate warrants the hope that although we have still to define the proper relationships between Ministers as trustees for the public interest and the numerous public boards, parliamentary criticism and debate on the nationalized industries of Britain may in future be concentrated increasingly on the proper objectives of policy and the merits or demerits of the particular means used to implement policy.

It could not be claimed, of course, that the debate indicated that the idea of the public corporations as trustees concerned with the efficient running of their affairs in the public interest has yet been fully accepted; but the atmosphere of the debate warranted a certain amount of confidence that we are progressing towards a clearer understanding of the proper use of the technical expert in the public service. To the technologist and scientist, interesting features of the debate were the references of the Minister of Fuel and Power, Mr. Geoffrey Lloyd, to the success of the National Coal Board's efforts in overcoming the shortage of technical men, particularly mining engineers, which has limited capital developments; to the changes in organization, making the Area the vital unit of higher management —a change conforming to the findings of the Acton Society Trust in recent studies; and to the examination of the whole organization of the Board which Sir Hubert Houldsworth proposes to institute.

Mr. Lloyd expressed the belief that developments in nuclear power would before long provide a useful addition to the resources of power in Britain, and he stated that the British Productivity Council has agreed to sponsor the non-profit making company which is being formed to take up the work of fuel efficiency. With the co-operation of industrialists, the Ministry is making a systematic survey of the generation and usage of steam by industry, which has already shown that one-fifth of the industrial boilers at present in use are more than forty years old. Replacement of these boilers by modern equipment offers savings estimated at two million tons of coal a year. He also said that the Government has introduced many of the higher standards recommended by the Ridley Committee and that many of the more efficient grates are coming into production.

While Mr. Lloyd claimed that there has been real progress in fuel saving, in the improvement of efficiency and in co-operation between the nationalized fuel industries and private industry, there were some significant omissions in his speech. Some of the strongest criticisms contained in the Ridley Report were ignored. His reference to the Minister's Co-ordinating Committee suggested that it is thought the Minister already possesses ample co-ordinating powers to ensure a national fuel policy so far as the fuel industries are concerned. Neither in his speech nor throughout the debate, save in Mr. A. Palmer's disparaging remarks, was there any reference to the report on fuel conservation, based on a visit to the United States last year of a specialist team on the conservation of fuel, heat and energy, recently issued by the British Productivity Council. This was the stranger because Mr. A. Robens, following the Minister, and again Mr. J. E. Powell, quoted Sir Ben Lockspeiser's recent remark: "We are still the champion coal wasters of Europe. We lack neither the science nor the technology to save from 15 to 20 million tons of coal a year, and at no greater cost than the additional expense we have had to shoulder by importing coal since the end of the war".

The importance of avoiding waste of fuel, in fact, received full emphasis in the debate, not merely as regards the domestic and industrial consumer but also in such matters as the location of power stations, the load factor in the electrical industry, and the necessity for an appropriate policy as one element in a national fuel policy. Even where it was contended, as by Mr. Powell, that the price structure advocated by the Ridley Report is inappropriate, the principle of co-ordination of the fuel and power industries in the national interest was fully endorsed; though it was contended that efficiency is best ensured by reasonable technical competition between the industries at a lower level and the preservation of some freedom of choice for consumers. Not all the implications of co-ordination were explored or indicated in the debate, but there was a most encouraging disposition to take a national point of view and not a sectional line. Weaknesses in regard to research and administration were noted, and the improvement of some particular condition was urged, not so much from the point of view of the workers affected as from that of the general benefit to the nation.

This in itself promises well for the future, and the various constructive suggestions made during the debate received a cordial welcome by the Parliamentary Secretary to the Ministry of Fuel and Power. Moreover, to the extent to which the efficiency of the individual industries depends, not merely on what are commonly termed industrial relations, but also on the outlook and spirit as well as the capabilities of the individual workers at all levels, the whole tone of the debate should be helpful. The question of accountability to Parliament of the public corporations may as yet remain unsolved; scarcely any reference was made to the recommendation in this connexion of the last report of the Select Committee on the Nationalized Industries, although Mr. G. Nabarro expressed the hope that the Standing Committee suggested would soon be constituted. Nevertheless, if Parliamentary scrutiny and discussion of the work of the public corporations continues on lines as constructive and objective as those of the debate of October 26, and the Ministers responsible show themselves in practice as responsive as the Minister of Fuel and Power appeared to be, the problem of securing efficiency and public accountability should be largely solved. Further, the temper and publicity of the debate should contribute also to remove misunderstandings and feelings of isolation, such as those to which Mr. Robson Brown and others rightly referred, and bring into all sections of the nationalized industries not merely a sense of the national interest, but also—and no less important—a sense of belonging to and being understood by the whole community.

That is not to say that all is well in the fuel and power industries of Britain, or that the Government has done all that is possible to formulate a national fuel policy, including an appropriate price structure, or to achieve savings in fuel. The Productivity Report on the Conservation of Fuel, Heat and Energy may call for criticism in some points: it did not deserve to be virtually ignored. Admittedly, it was what has been called an 'angry' report; and the specialists have perhaps overlooked the importance of the human factor, both on the production and on the consumer side, which Mr. Aubrey Jones rightly stressed in the House of Commons debate. Personality is more important than organization, to the extent that without it even the soundest policy or the most perfect organization will not function. Effective leadership turns above all on personalities, and for that reason alone the content of overall fuel policy and the means necessary for implementing it must take more account of the human element than the specialist team appears to have done. Public apathy and inertia may be deplorable and irritating, but they represent a factor of which due account must be taken both in the formulation of policy and the choice of means of executing it.

The virtual ignoring of this report in the House of Commons and by the Government is not to be excused on the grounds of over-emphasis on the part of the experts concerned. It can only be condoned when the Government itself produces a fuel efficiency programme, comparable in extent and urgency with that urged by the team, and shows that it is tackling the difficulties in the way of framing a national fuel policy much more vigorously than was evident in either Mr. Lloyd's opening speech or Mr. L. W. Johnson-Hicks's reply on the debate. The debate did not supply evidence that fuel saving has yet the place it should have in the programme of the Government or that, even with the new Fuel Efficiency Organization, enough will be done to further public education in this matter.

It is true that there is not a great deal that is new about the conclusions and recommendations of the Productivity Report on fuel. None the less, they give a useful, if somewhat authoritarian, statement of

measures required and of the priorities, though the recommendation for the establishment of a commission to formulate a national fuel policy or for the co-ordination of the nationalized coal, gas and electricity industries under a Fuel and Power Board ignores the co-ordinating powers which the Minister already possesses—even if he has made scant use of them. More could undoubtedly be done to provide effective financial incentives to encourage industry to install efficient fuel-burning plant and equipment, and a large measure of responsibility lies on the Government also for the encouragement of co-operation in joint services for the supply of steam and power instead of by generation of steam in individual works and factories, seeing that financial and taxation policies do so much to discourage investment of this kind.

The Productivity team may well have erred in under-estimating the other factors in the situation when urging the installation of new and efficient plant and appliances either in industry or for domestic use, and it appears to go too far towards dictatorship. The relation between the cost of labour and the cost of equipment to replace it has to be considered, as well as the cost of the energy generated and used by the equipment, with which the team is inclined to be preoccupied, in discussing or comparing industrial fuel practice in the United States and here. This discussion, probably the most useful feature of the report, is rather obscured by the more contentious recommendations which precede it. The team believes that a higher level of efficiency in the utilization of fuel and power prevails in the United States than in Britain, and on the evidence it presents this conclusion may be right. Further, it regards the development and rapid expansion of American industry as directly reflecting a vigorous exploitation of ample supplies of fuel and power, energy consumption per head of population being by far the highest in the world. The stores of energy in the United States are so vast and relatively inexhaustible that there are no inhibitions as to its use, nor is there great anxiety as to future supplies.

In this context, it must be remembered that in the United States 54 per cent of the energy used comes from sources such as oil, natural gas and hydroelectricity, 'fuels' inherently easier to handle and less likely to be wasted than coal, whereas in Britain coal supplies 90 per cent of all energy used. Again, while American industry is disposed to replace all its equipment sooner, this is not due simply to a more favourable financial policy. The ratio between the cost of labour and the cost of equipment to replace it differs in the two countries, and how far British industry should go in this direction depends eventually not simply on thermal efficiency but on the return to be obtained on investment. Government policy can increase or decrease that return but only within limits, and Britain's overwhelming dependence on coal thus sets limits to what can be accomplished by educational campaigns or a fuel-efficiency organization.

As has already been urged, the importance of financial incentives, in the way of tax reliefs rather than loans, should have received greater emphasis as the only effective means of furthering fuel efficiency in those branches of industry in which the cost of fuel is a secondary factor. Apart, however, from the prevailing apathy to fuel economy, sociological factors are so important that the Productivity team is not to be rebuked for straying into such fields instead of confining itself to purely technical questions. Even in the happier atmosphere of the House of Commons debate, which did something to meet the team's hope that the fuel industries might be considered from a national point of view and not from that of political parties, the report and its reception raise afresh the issue of securing effective action on technical advice. Moreover, as Sir Harold Hartley remarked in his recent Melchett Lecture to the Institute of Fuel, particularly in considering domestic fuel problems, psychological as well as economic and technical factors are important. Clearly, as Sir Harold indicates, the fuel industries could do more than they have yet done, even in the past quarter of a century, to create the conditions favourable for progress in the use of more efficient appliances. That could also be encouraged further by the Government, and financial policy or pricing policy could be a powerful determinant, too, in the choice of particular types of fuel, as well as of appliances. Except, however, in the broadest terms, it is difficult to see that the Government could go far in formulating a long-term policy, other than the removal of anachronisms and such competition between the fuel industries as is detrimental to the national interest. What matters above all is to see that attention to efficiency at a particular time does not impede the receptiveness to new ideas. As Sir Harold remarked further, it would be unwise to take any decision in regard to domestic or industrial heating which would determine for years to come the direction in which development must take place. Real progress, the most effective utilization of all Britain's limited fuel resources, will only be ensured if technologists are afforded full scope. If, for example, means are found of applying the principles of the heat pump to equipment which can be used in houses, the balance of demand would be markedly affected, and electricity and gas might then begin to acquire a large part of the load.

There were other ideas ventilated in the House of Commons debate, and it is for this reason that the slender expenditure on research of the British Electricity Authority is disturbing. Its fifth annual report recorded an expenditure of only £138,835 on research in 1952–53 compared with £140,327 in the previous year; and this small figure has to be set against a fall in the load factor of generating equipment to 44·9 per cent compared with 47·4 per cent in 1951–52. Possibilities of improving this and of saving coal consumption, for example, by the use of gas turbines, are indicated and discussed in the report itself. For the same reason, the decision of the Gas Council to spend a million pounds during the next five years on surveys of parts of Yorkshire, Lincolnshire and Scotland for sources of natural gas is to be welcomed; the surveys are being carried out for the

Council by the d'Arcy Exploration Company, a subsidiary of the Anglo-Iranian Oil Co., Ltd.

Besides this, the Gas Council proposes to investigate the further improvement of methods of production, and Sir Harold Smith has pointed out that success in these ventures would transform the whole economics of the gas industry. The rise in the price of coal since vesting day has added £25 millions to the Council's annual coal bill: the last rise of 10 per cent in pithead prices, which came into force on March 2, 1953, is estimated as costing the gas industry more than £8·5 millions in a year. Moreover, coal for gas-making is getting scarcer as well as dearer. The country's reserves of high-grade coal necessary for gas manufacture are running out, and the Gas Council and the Coal Board are both anxious to find effective substitutes.

Nevertheless, though there is plenty of room for research and need for a more vigorous policy than is evident in the latest report from the British Electricity Board, the two chief requirements in regard to the utilization of fuel in Britain are, first, Government intervention to secure concerted action and policy on the part of the fuel industries rather than the independent and sometimes conflicting policies and lines of action pursued by the coal, gas and electricity corporations—actions of which the Productivity team rightly complains; and second, the effective utilization of existing knowledge. Remedies for most current abuses in the use of fuel are well enough known. What is needed is a vigorous campaign, with possibly some further Government encouragement in the way of financial incentives or taxation relief, to secure action on that knowledge. No fresh organization or commission such as the Productivity team suggests will have much effect if the Government, or the Minister, is reluctant to use the powers and knowledge already available. The avoidance of waste of existing fuel supplies, the increase of efficiency of production and the development wherever possible of fresh sources of fuel and power, are matters of urgency for the immediate as well as for the more distant future of Britain.

PLANTS OF THE BIBLE

Plants of the Bible

By Dr. Harold N. Moldenke and Alma L. Moldenke. (A New Series of Plant Science Books, Vol. 28.) Pp. xx+328+36 plates. (Waltham, Mass.: Chronica Botanica Co.; London: William Dawson and Sons, Ltd., 1952.) 7.50 dollars.

POLITICAL upheaval and racial strife apart, much has happened in Palestine during the twentieth century. Each decade has revealed extraordinary archæological treasures: the chance findings of the ancient Scrolls of the Law in a cave near the Dead Sea; the systematic researches resulting in the discovery of the ivories in Ahab's summer palace at Samaria; and the recent find of the seven thousand year old clay portrait-busts on human skulls at Jericho. With the advent of hydroelectric power and irrigation schemes, enormous strides have been made in agriculture, horticulture and botany, and this has brought a renewed interest in the plants of the Bible, an interest so strong that at the Hebrew University of Jerusalem there is now a professor of biblical botany, Dr. Ha-Reubeni, who already has thrown much valuable light on this fascinating subject and no doubt will continue to do so.

On no other aspect of botany has so much been spoken and written, by so many people, in so unscientific a fashion. In my opinion, Dr. and Mrs. Moldenke's book is the most authoritative and comprehensive statement on the plants of the Bible that has been published. Theirs is a completely new scientific survey of the subject. As well as making researches into the works of classical and historical translators, they have consulted all the contemporary translations and commentaries of the Protestant, Catholic and Jewish Bibles, and the result is a well correlated volume equally accessible to the readers of these three great faiths, as well as a most extensive bibliography of more than six hundred items in which it is surprising to find no reference to Hasting's "Dictionary of the Bible" nor to Sir George Adam Smith's "Historical Geography of the Holy Land".

Including algæ, fungi and bacteria, some two hundred and fifty plants are alphabetically listed and described under their botanical name. The reason for this sequence is not clear, and surely it would have been more convenient to have had the plants arranged alphabetically under their Bible names. This is a book not only for botanists but also for Bible scholars and others as well; and not all botanists by any means (let alone non-botanists) will know that for an account, for example, of the "juniper" of the Scriptures they must turn to the chapter on *Retama raetam* (Forsk.) Webb. and Berth., or for an account of the "hyssop" to the chapter on *Origanum maru* L. With the present arrangement, one spends a lot of unnecessary time with the index.

Always there have been differences of opinion about these Bible plants, and of some of them no doubt there will always be differences of opinion. Dr. and Mrs. Moldenke, in their many discussions, present their case fairly and without prejudice to other writers. One wishes, however, in many instances that their own arguments and the arguments of others could have been presented in greater detail. Why, for example, do the authors regard *Narcissus tazetta* L. as the "rose" of Isaiah 35 : 1, and why do all modern commentators refuse to accept Royle's scholarly arguments that the "hyssop" was the common caper *Capparis sicula* Daham? In such matters as these this book lacks the interest to the general reader which Canon Tristram so superbly gave.

There are twenty pages of supplementary notes with, and most important, a promise of further supplements to appear from time to time in "Chronica Botanica". These notes bring up to date completely our knowledge of Bible plants, and some of them are of very great interest indeed. For example, the discovery of *Lilium candidum* L. growing wild and apparently indigenous on the mountains of Upper Galilee near the frontier between Palestine and Lebanon suggests that this plant may have had a fairly wide distribution in the time of Christ and possibly may have been the "lilies of the field" for which *Anthemis palestina* Reut. was postulated in 1925 by Dr. Ha-Reubeni.

There are many illustrations; some are of mythological figures and some are of reproductions and original drawings of the plants discussed in the text. All these are good. The woodcuts, however, at the end of certain chapters are insufficient for purposes of identification and serve no useful purpose. Moreover, it is a pity that no modern photograph of Israel and Jordan has found a place in this modern text-book on Bible plants. Those plates which attempt to portray the scenery of the Holy Land are wood engravings from C. W. Wilson's "Picturesque Palestine", published in 1883. H. R. FLETCHER

PENCK'S "MORPHOLOGICAL ANALYSIS"

Morphological Analysis of Land Forms

A Contribution to Physical Geology. By Prof. Dr. Walther Penck. Translated by Dr. Hella Czech and Katharine Cumming Boswell. Pp. xiv+429+12 plates. (London: Macmillan and Co., Ltd., 1953.) 42*s*. net.

WALTHER PENCK'S "Die Morphologische Analyse" was published in 1923, after his death at the age of thirty-five, by his father, Albrecht Penck. The original German work was written in a manner difficult to read for anyone except an expert linguist and for that reason may not have received as much notice as it should have done at that time.

The present translation by Dr. Hella Czech and the late Miss Katharine Boswell emphasizes the difficulty. They have kept the translation as literal as possible; but even so, it must be admitted that the present book is far from easy to read. Yet if they had not done this, they would have had to give an interpretation rather than a true translation of his book. Whether or not the volume will succeed in making clear Penck's views is debatable. Miss Boswell, whose sad and premature death took place before the appearance of the volume, has added some valuable summaries of each chapter; but despite the care she has given to them, they do not entirely succeed in making clear the precise implications of the full accounts.

Penck was particularly concerned with slopes—their shapes, declivity, development, and so on. He has been responsible for provoking a great deal of work on this problem, which is one of fundamental importance. He correlated the form of the slopes with earth-movement, and assumed that the initiating condition for the development of land forms was a long-continued and very slow upheaval, which might affect either a newly developed basin of sedimentation or an old peneplain, or some variant of these forms. Unlike W. M. Davis, he did not consider development under the heads of youth, maturity and old age, but in terms of an analysis of the developing slopes. In brief, waxing or accelerated (*aufsteigende*) development implies convex slopes and relatively quick upheaval, waning or declining (*absteigende*) development leads to concave slopes because the movement by upheaval is dying out, and uniform (*gleichförmige*) development implies a balance between slope evolution and diastrophic movement. Penck, in fact, thought of morphological analysis as the means of deducing the nature of crustal movements from the landscape features themselves as well as from the (exogenetic) processes working on them. He insists that the problem is that of crustal movement, and that it falls in the realm of geology.

To develop his views on slope evolution Penck analyses in some detail the processes of weathering, the ways in which rock debris is formed, the laying bare of surfaces, and the whole question of the removal of waste. This is termed 'denudation' (*Abtragung*), a word which he does not apply to stream 'erosion'. 'Corrasion' is defined as "the freeing of loosened rock-fragments from the place of origin". The reader must therefore appreciate Penck's terminology. Penck's hypothesis implies, too, that the angle of slope retreat will be maintained as long as the factors initiating it are not altered—in short, there is parallel retreat of slopes. Even where down-cutting ceases, parallel retreat of the upper slopes is maintained; but new processes begin to work on the foot of such slopes, since conditions now mean that, apart from lateral corrasion, the stream cannot remove the waste accumulating from above. "The under surface of the talus is always a slope with a gradient less than that of the rockface above. This is the basal slope (*Haldenhang*). . . . Where the basal slope meets the rock wall . . . is the top of the basal slope (*Haldenscheitel*). The accumulation of talus does not simply bury the rock wall and thereby remove it from further decay; but together with the inclined basal slope, it grows upward at the expense of the wall."

It is helpful that this translation has appeared because for the first time it may introduce Penck's treatise to a number of readers who would otherwise have had to learn about it indirectly. It is doubtful if it will make his conceptions completely clear. It should be remembered that he intended to publish a larger work in which he would have developed his thesis more fully. Physiographers have found Penck's ideas provocative, although many now would challenge his correlations between diastrophism and slope form. But one must ask: Is this translation not too delayed relative to the publication of his original book? It may seem ungracious, but it is worth suggesting that a lengthy essay written by someone familiar with both Penck's work and with the field evidence of the subject-matter is really what is required. J. A. STEERS

LABORATORY EXPERIMENTS WITH RADIOACTIVE MATERIALS

Experimental Nucleonics

By Prof. Ernst Bleuler and George J. Goldsmith. Pp. xv+393. (London: Sir Isaac Pitman and Sons, Ltd., 1953.) 30*s*. net.

THIS book is concerned with laboratory experiments originating from a course at Purdue University in the United States. The experiments relate to radioactive materials and the techniques used for measuring and separating them, and they are intended as part of the fundamental training of "people who anticipate performing tracer research as well as students of nuclear physics". The text is divided into three parts allotted respectively to techniques of counting and handling, with general applications; experiments in radiochemistry; and experiments dedicated to students of nuclear physics itself. Biologists, engineers and civil-defence per-

sonnel are among those who will also find the first section relevant.

Interest in this kind of book obviously appears mainly among those concerned with education and training, though industrial and government establishments may be included in this category as well as schools, universities and colleges. Although teachers will enjoy comparing the suggested courses with their own, the book should be regarded as a reference work, for there are detailed and careful sections on equipment, experimental procedure, and "evaluation and report", which make continuous reading heavy going. Also, in Britain, rigid adherence to these sections in a laboratory course is not very probable, as much of the apparatus and some of the materials used at Purdue are different from those generally at hand here. (Some of the references are also less accessible here. For example, United States Department of Commerce publications relating to health hazards and precautions may be less attractive than the "Introductory Manual on the Control of Health Hazards from Radio-active Materials", available from the Isotope Division at Harwell.) Teachers may also feel that these detailed experimental instructions leave too little to the student's imagination. On the other hand, the sections on the theoretical background which accompany each experiment lose little of their value in crossing the Atlantic. Apart from the variations in symbols and notation, which, as the authors say, are an inevitable feature of nuclear study at present, these sections would apply to almost all introductory laboratory courses in the techniques relating to radioactivity.

The experiments described in Part 1 would be generally accepted as suitable material for this kind of course. They include Geiger counter and ionization chamber techniques, but scintillation counting is relegated to the nuclear physics section, and the proportional counter has only scanty treatment. Some amplification of the neutron mean-life experiment would increase its value to engineers studying nuclear energy; for example, indium foil activation enables the neutron distribution to be examined.

The remaining parts of the book describe experiments which are best regarded as further training in the techniques dealt with in Part 1. The chemical and physical theory involved is not in itself up to honours degree standard, while there is no extensive investigation of possible applications of the techniques of radioactivity in research in either field. The references at the end of each chapter, which include publications up to 1951, do enable more elaborate or comprehensive ideas to be followed up, however.

R. L. Fortescue

APPLICATIONS OF ELECTRICITY IN HORTICULTURE

Electricity in the Garden

By Geoffrey Gerard. Pp. x+125+16 plates. (London: W. H. and L. Collingridge, Ltd.; New York: Transatlantic Arts, Inc.. 1953.) 15*s*. net.

THE Briton is an invetera gardener. In few countries can there be a greater proportion of keen amateurs, assiduously cultivating their home plots, often under far-from-promising climatic and topographical conditions. It is good that this should be so. We needed all the home-grown food that could be produced during the War and, if shortages are now less acute, there is still profit—and much pleasure—to be gained from gardening as a hobby. As electricity has become a great benefactor in the home, so it can be also in the garden. Electrically operated appliances for the garden are not really new but, in spite of their continued development during the past two or three decades, and the publicity which has been given to them from time to time in gardening journals and at horticultural shows, they are not as widely appreciated as they should be. Mr. Geoffrey Gerard's book is thus opportune. It should be very useful to the knowledgeable gardener in providing him with information on the best methods of using electrical equipment which he may already possess, or may acquire, as well as giving, for the benefit of the uninitiated, a comprehensive account of the possibilities. But the book is not confined to matters of interest only to the amateur; electrical methods for soil warming in frames and glasshouses, space heating and artificial illumination certainly concern the professional grower, and many of the illustrations are taken from commercial practice.

There are, of course, several important factors, varying widely in natural conditions, which affect the growth of plants—light, air temperature and humidity, soil temperature and moisture content, and the carbon dioxide content of the air as well as the chemical, bacteriological and mechanical conditions in the soil or other growing medium. In spite of research extending over many years, we are still far from knowing exactly what relative values of these quantities are required to bring about optimum growth at different stages of the development of plants; but plant physiologists such, for example, as Dr. F. W. Went, of California Institute of Technology, seem to be approaching the point where they can give a 'recipe' for growing some of the more important horticultural crops. If they succeed in doing so there is little doubt that electrical methods of controlling these factors precisely can be found. The problem for the commercial grower will then be to decide how far he can afford to go in applying these methods in his practical operations. Mr. Gerard's book does not attempt to instruct the grower in such economic matters but, at least, the author has taken pains to present the results of up-to-date research and development. He has drawn freely on the Electrical Research Association's reports upon its electro-horticultural researches at the Shinfield Field Station, and has given full references to these and other publications which can provide the interested reader with more detailed information.

It is good to note also the care which has been taken to point out the dangers of bad workmanship in installing the necessary electrical equipment. The chapters giving some instruction on the elements of electrical engineering and on maintenance of the installation are appropriate and are clearly written, and there is also an appendix giving the Draft British Standard Code of Practice for Farm and Horticultural Electrical Installations.

The book is well produced, and both the photographic and line-drawing illustrations are particularly good. If one feels that its price is rather high, that may be due to the difficulty in growing accustomed to the present-day costs of producing a book of this kind.

E. W. Golding

BRITISH RAILWAYS WIND TUNNEL

By D. W. PEACOCK

WIND tunnels, indispensable in aeronautical research, are increasingly being recognized as equally successful for aerodynamic problems in other fields of engineering, and it was with these considerations in mind that in 1934 the directors of the former London, Midland and Scottish Railway authorized the installation of a wind tunnel in the L.M.S. Research Department at Derby. The most important aerodynamic problem at that time was the streamlining of locomotives and trains, on which useful work was done, while it was later found that the wind tunnel was increasingly employed on a large variety of railway aerodynamic problems[1]. The tunnel was of the straight-through type, with its design based on similar tunnels in use at the National Physical Laboratory at the time. It had a working section 4 ft. 6 in. wide by 3 ft. 6 in. high, 14 ft. 3 in. long, and was capable of a maximum speed of 60 miles per hour. The tunnel gave satisfactory service until it was necessary in 1952 to move it from its site, and the opportunity was then taken to build a new 100 m.p.h. wind tunnel, incorporating the working section of the old tunnel and its electrical driving gear, and using the same test apparatus. Incidentally, it is believed that the old tunnel and its successor are the only railway-owned wind tunnels in the world in regular use.

The new tunnel has recently been brought into operation and was opened on October 19 by Dr. F. C. Johansen, of the Avery Research Administration, who, when engineering research officer for the L.M.S. Research Department, pioneered and installed the first wind tunnel. The new tunnel is housed in a converted building near the main British Railways Research Department building at Derby, and the general arrangement is shown in Fig. 1. The tunnel construction is mainly in wood, with ply-wood walls or lining, and the fan section is steel, the interior surfaces being painted and varnished to give a good smooth continuous finish. The tunnel is of the closed-working section return-circuit type which gives good airflow conditions and

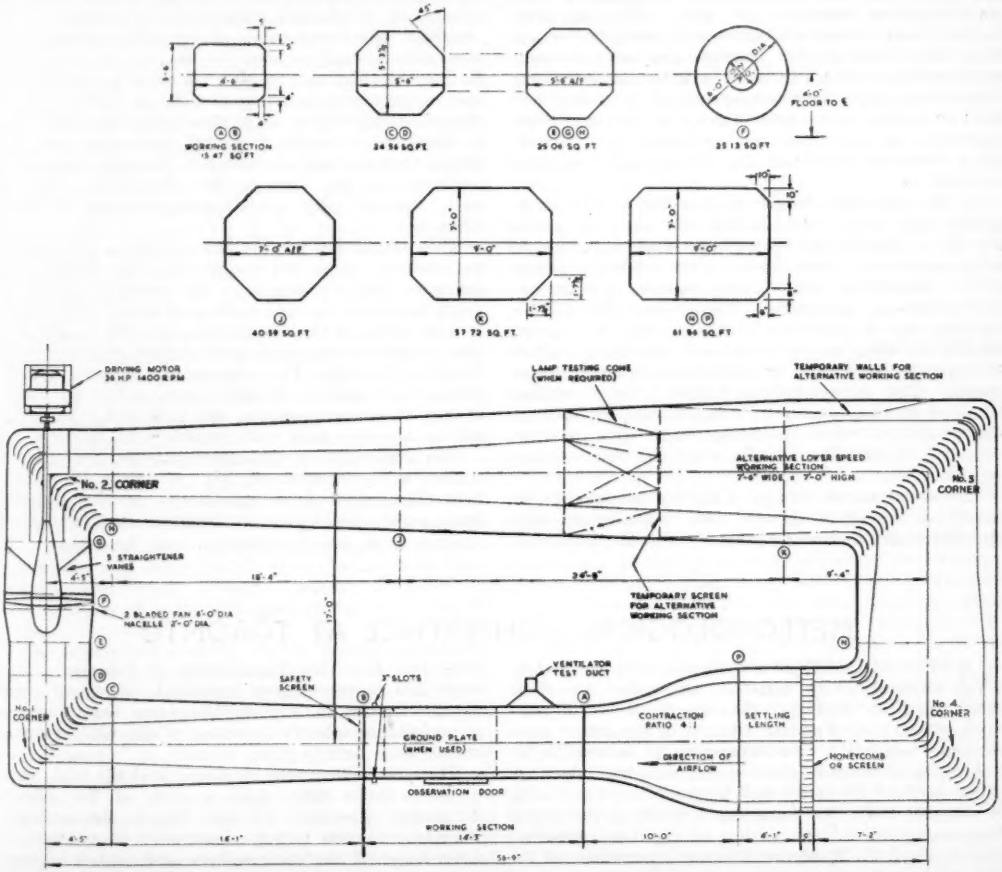


Fig. 1. Line diagram of the Derby return-circuit wind tunnel : scale ¼ in. to 1 ft. Corners 1 and 2, 16 turning-vanes ; corners 3 and 4, 26 turning-vanes

economical use of power. The working section from the old tunnel has been renovated and adapted, and slots are cut in the walls at the downstream end to establish the static pressure as atmospheric. A 4-in. mesh safety screen of streamlined wires is fixed here to catch any part of a model which may accidentally break loose.

From the working section the air passes along an expansion to the first corner, which is fitted with thin turning-vanes made of rolled aluminium sheet, the same turning-vane section and pitching being used at all the four corners. The general layout of the tunnel led to the fan being most conveniently situated between the first and second corners. It is two-bladed, 6 ft. maximum diameter with a 2 ft. diameter boss and nacelle, the blades being made of laminated mahogany, covered with a plastic skin impervious to moisture. The fan is directly coupled, by a long shaft which passes through the tail of the nacelle and through a fairing at the second corner, to a 36 h.p. 1,400 r.p.m. direct-current motor situated outside the tunnel, the electrical equipment being of the Ward–Leonard type, which provides accurate and economical speed control from crawl to full speed. The nacelle is supported immediately downstream of the fan by five symmetrical aerofoil straightener vanes which remove any rotation in the airstream, and the fan section is designed with approximately constant net area. The air then passes round the second corner and along the return duct, where the section changes gradually to rectangular 9 ft. wide by 7 ft. high. (with corner chamfers). Throughout the circuit the equivalent cone angles of the expansions are no more than 4·8°, the maximum expansion in any plane not exceeding 7·1° (except for a short length across the chamfers at the third corner).

At the third and fourth corners the largest cross-section has been reached, and the air then passes through a honeycomb 9 in. long with 2-in. square cells, made of brass sheet with soldered joints, which breaks up eddies and smooths out irregularities in the airstream. The honeycomb can be replaced by a phosphor-bronze screen of 14-mesh 24 S.W.G. wire, to give increased quality of airflow at the expense of some reduction in maximum tunnel speed. The honeycomb is followed by a settling length 4 ft. long, and a 4 : 1 contraction 10 ft. long, the profile of which is designed to give uniform velocity distribution at the start of the working section.

The aerodynamic design of the tunnel was undertaken by British Railways, after consultation with the National Physical Laboratory and the College of Aeronautics, Cranfield. The fan design and general construction of the tunnel were carried out by the Airscrew Company and Jicwood, Ltd., Weybridge; the tunnel was built in sections at their works and assembled on site at Derby.

Standard wind-tunnel instruments are employed for the determination of air forces and speeds. Two general-purpose single-component balances are available, and wire suspensions are employed to connect the models to the balances. This arrangement, though having a high suspension drag, enables simple balances to be used, and has given good results. Pressure plotting can be carried out by the use of a multitube manometer. Equipment is provided for flow visualization by the use of smoke generated by dropping paraffin or lubricating oil on an electrically heated hot-plate. Models of locomotives and rolling stock are tested over a thin flat plate representing the ground, and for the sake of simplicity a fixed ground-plate has been employed.

A full-sized railway signal can be put into the working section for testing oil-burning signal lamps, and a test duct is installed for railway coach and roof ventilators. In the return section provision has been made for the temporary fitting of a plywood contracting cone which enables a 60 m.p.h. jet of air of about 4 ft. diameter to be produced for the testing of shunters' hand lamps, where both the effects of wind and manipulation require to be obtained simultaneously, or for other tests where the investigator requires to be in the airstream. Before the third corner, there is room for an alternative lower-speed working-section in which can be placed a larger site model in the study of such problems as dispersal of smoke from tall chimneys, and it is hoped that the airflow here can be made reasonably uniform by the temporary fixing of one or more screens, with a maximum airspeed of about 22 m.p.h.

The tunnel has so far been given a preliminary calibration, which has shown that the velocity distribution and steadiness in the working-section are good, and that the speed attained with a clear tunnel is 112 m.p.h. with honeycomb, and 98 m.p.h. with screen, both being taken with an output from the fan motor of 36 h.p. The corresponding power factors, defined as ratio of horse-power to fan to kinetic energy at working-section, are 0·24 and 0·36, values which compare well with similar wind tunnels.

The immediate programme proposed for the new tunnel includes work on air resistance of wagons, heat dissipation from axle-boxes, smoke dispersal from engine sheds, and the design of roof ventilators.

[1] Peacock, D. W., *Inst. Locomotive Eng. J.*, **41**, 606 (1951).

METEOROLOGICAL CONFERENCE AT TORONTO

METEOROLOGISTS are notably and necessarily internationally minded, and the American Meteorological Society, the Royal Meteorological Society and the Canadian Branch of the latter have recently realized a new expression of this spirit by holding a successful—first—joint meeting. It took place in the University buildings at Toronto during September 9–15, the Canadian Branch of the Royal Meteorological Society acting as the very generous hosts. Prof. H. R. Byers (Chicago), president of the American society, sowed the seeds of the meeting, and its realization was made possible by a generous grant from the Munitalp Foundation of America. More than 250 meteorologists attended, of whom about twenty formed the British delegation from overseas. A necessarily selective account of the nine symposia which were held is given below.

The first session was on ozone and the high atmosphere, under the chairmanship of Sir Charles Normand, president of the Royal Meteorological Society. It was largely descriptive in content, for knowledge of the stratosphere and higher layers is not yet sufficiently precise and comprehensive to evoke a well-conceived dynamical theory which, it is

now at least evident, is required to give meaning to the observed structure; radiation thermodynamics is certainly not enough, although there is much work for it to do. An admirable survey of ozone behaviour by the chairman suggested, however, that dynamical meteorology might well soon profit by much of the evidence now accumulated on the spatial and temporal distribution of ozone. Recent additional studies of its vertical distribution were presented by F. S. Johnson (U.S.), from rocket solar spectra, and by R. M. Goody (Great Britain), from ultra-violet and infra-red solar spectra observed at the ground. Temperatures and winds at high levels as currently measured by means of sounding balloons, from the propagation of sound, by observations on noctilucent clouds and by means of ionospheric radio reflexions were described; but a coherent picture of the motions, and of the thermal gradients in the meridional and vertical directions, did not emerge.

The second symposium, on radiation problems, under the chairmanship of Dr. G. D. Robinson (Great Britain), was appropriately divided into three sections, one on the methods of computation of the flux of atmospheric radiation, a second on laboratory investigations of infra-red spectra, and a third on the application of radiation studies in physical climatology. The material of some of the speakers was too detailed for immediate apprehension by all but a very few specialists, and will wait on more suitable occasions for appraisal. It is, however, evident that the complexity of infra-red absorption and emission in the atmosphere is slowly being mastered, to the end of computing reliable values of flux and, more particularly, of flux divergence (position and strength of radiation heat sinks) in model atmospheres. The validity of simple, approximate treatments for day-to-day application might then be tested. An interesting 'savoury' to the discussion was provided by A. W. Brewer's report of the first actual measurements of atmospheric radiation above the tropopause by Houghton at Oxford.

Canada now has an extensive network of Arctic *radio-sonde* stations, and it was appropriate, therefore, that a session should have been devoted to Arctic meteorology, with Andrew Thomson, controller of the Canadian Meteorological Service, in the chair. H. U. Sverdrup (Norway) showed how certain problems in atmospheric radiation and heat transfer are peculiarly amenable to investigation in high latitudes owing to the absence of solar radiation and the presence of snow surfaces with extreme thermal properties. Results obtained on the recent Norwegian–British–Swedish Antarctic Expedition were also presented. F. W. Rae (Canada) spoke on the setting up and maintenance of an Arctic *radio-sonde* station, and H. P. Wilson (Canada) described an investigation of cyclone behaviour within the Arctic Circle.

The next three sessions, on the general circulation of the atmosphere (chairman, Prof. P. A. Sheppard, Great Britain), on modern cyclone theory (chairman, Prof. S. Petterssen, U.S.) and on high-level forecasting (chairman, General W. O. Senter, U.S.) may conveniently be treated together as atmospheric dynamics and thermodynamics. The mean wind systems of the globe up to a height of about 20 km. are now becoming tolerably well established, and the problem is to account for their maintenance against dissipative processes and in the presence of large-scale turbulence provided by the migratory long waves, cyclones and anticyclones, and of other, smaller-scale motions, the whole to conform with the distribution of energy sources and sinks. Papers were presented describing the momentum transfer by turbulence from low to high latitudes and in the vertical, and there was some speculation on the role of quasi-steady large-scale overturning of the atmosphere in meridional planes (mean meridional circulations) in the general circulation. These necessarily small mean meridional motions are difficult to establish where zonal motions many times larger are present, as is mostly the case. But they can be most important in the creation of relative (air to earth) zonal or angular momentum, because of the earth's rotation.

Cyclones not only play a fundamental part in the transfer processes of the general circulation but are also, of course, of intrinsic interest and great practical importance. While it has been shown that, for example, a westerly current which increases with height may be dynamically unstable and so give rise to disturbances of the scale, form and growth-rate and perhaps with the transfer properties which we observe, other forms of shearing instability are regarded as possible, and J. Bjerknes (U.S.) spoke on these. The nature of the instability in individual cases is, however, scarcely identifiable, and a new technique of investigation is now being exploited. This is to carry out numerical integrations of the hydrodynamical equations of motion, using electronic digital computers, and working from initial observed states of the atmosphere. The equations are first simplified to such a form as is thought valid for developments of the scale concerned. J. G. Charney (U.S.) described a particularly strong case of cyclonic development computed in this way, and gratifying success over 24-hr. intervals was achieved. The particular simplifications of the equations correspond, of course, to assumed model behaviours of the atmosphere, and already a sequence of models of increasing complexity has been investigated in a search for that model which is sufficiently realistic and also amenable to machine computation. The application of the technique to day-to-day forecasting is not the least of its potential rewards.

The jet stream of the upper troposphere remains obstinately outside current dynamical theory, but much work of a descriptive kind on the behaviour of the jet and on smaller-scale motions associated with it, some made visible by aircraft condensation trails, is in progress and was reported upon.

Sessions on climatic change (chairman, Prof. G. Manley, Great Britain) and on micrometeorology (chairman, Dr. C. W. Thornthwaite, U.S.), that is, on the extreme ends of the atmospheric turbulence spectrum, produced a crop of papers indicative of the current activity in these fields. It was particularly appropriate to hear speakers discussing the phase differences of climatic change on the two sides of the Atlantic, and as intriguing as ever to note the diverse forms of evidence which are brought to bear, with more or less certainty, on this problem. Fact-finding is still the need, though the facts for times before the instrumental records begin must necessarily be transformed by imagination controlled by critical power. Theorizing is not at present of great power; for here, as much perhaps as elsewhere in meteorology, cause and effect seem to be almost inextricably mingled.

The micrometeorologists ranged from the very practical problems of the micro-climate of the potato crop and of atmospheric pollution to the sophisticated

investigation of isotropic and anisotropic turbulence near the earth's surface. The difficulty in separating turbulence from mean motion in the latter work was again made manifest. Dr. H. Lettau (U.S.) concluded this symposium with a colour film of a large joint project undertaken a month before on the great plain of Nebraska, where a dozen or so teams compared their methods of measurement of mean profiles and the vertical transfer of momentum and heat.

The final symposium, on cloud physics and induced precipitation, under Prof. H. G. Houghton (U.S.), began in the laboratory and ended in large-scale weather systems. It is now well known that the laws of supercooling of water droplets are intimately concerned in the colloidal stability of clouds, and Dr. C. L. Hosler (U.S.) showed how supercooling increases with decrease in drop size and increases or decreases according to the nature and amount of the hygroscopic material forming the nucleus of the drop. Radar studies of precipitating cumulonimbus clouds by the Chicago school have shown how the initial radar echo, that is, the region containing precipitation particles as opposed to cloud droplets, appears wholly below the 0° C. level and later grows both upwards and downwards. This was interpreted as evidence that the ice-phase is not essential in inland areas such as Illinois for the initiation of shower precipitation, but no mechanism of initiation was suggested. If the interpretation is sound, the stimulation of a cloud to produce precipitation using ice-forming agents can scarcely be adequate. K. G. Pettit (Canada) described cloud characteristics as inferred from aircraft-icing investigations, and the Massachusetts Institute of Technology school presented the results of a very detailed investigation of five depressions by aircraft, ground radar, etc. They relate precipitation patterns to cloud development, cloud-particle form and concentration, frontal structure and upper-level flow fields—an investigation, it appears, from which much may ultimately be inferred on the physics, including the dynamics, of the production of cloud and precipitation in the depressions which constitute so much of temperate-latitude weather.

The Conference was stimulated by a number of social functions: a conversazione by the Canadian Branch of the Royal Meteorological Society on the first evening, a reception by the Lieutenant Governor of Ontario, an excursion to Niagara Falls, and a cocktail party (by the Friez Instrument Co.) and dinner on the last evening. The dinner was notable for speeches from the Minister of Transport for Canada and from Mrs. C. Beech, of the Munitalp Foundation, and for the announcement of the election by the American Meteorological Society of the first six honorary members on its roll: of these, five were British—Sir David Brunt, Sir Nelson Johnson, Sir Charles Normand, Mr. J. Patterson (Canada) and Sir George Simpson; the sixth was the distinguished Norwegian geophysicist, Prof. H. U. Sverdrup.

P. A. Sheppard

COSMIC-RAY PRODUCTION OF HELIUM IN METEORITES AND THEIR AGES

By Dr. J. C. DALTON, Prof. F. A. PANETH, F.R.S., Dr. P. REASBECK, Dr. S. J. THOMSON
Londonderry Laboratory for Radiochemistry, University of Durham
and Dr. K. I. MAYNE
Clarendon Laboratory, Oxford

IT has recently been proved that a major part of the helium found in iron meteorites is due to the influence of cosmic rays[1]. This interaction should produce helium-3, helium-4 and tritium (see, for example, ref. 2), and the tritium will have decayed in geological time to helium-3. Helium-3 has been measured by mass-spectrometry in the helium from meteorites. If the ratio of helium-3 to helium-4 for helium produced by cosmic rays could be assessed accurately, then ages of meteorites could easily be calculated by the classical radioactivity method; but the ratio is dependent on the excitation energy of the iron nuclei which produce the helium and tritium by evaporation processes, and is therefore not constant at different points within meteorites. However, approximate limits to this ratio can be set in a number of ways.

Le Couteur[3] has predicted a ratio of the order of 0·3, and in helium from the meteorites so far examined the highest observed ratio is 0·315. A study of the variation of the ratio with depth in a large meteorite, "Carbo"[1b], showed a change in the ratio from 0·288 at a depth of 3 cm. to 0·277 for 29 cm. depth of iron. The helium content decreased also, and the values obtained theoretically by Martin[4] for the dependence on depth of the amount of helium produced by cosmic rays were in excellent agreement with the experimental values.

An estimate has been made by one of us[5] of the probable limits of the ratio helium-3 to helium-4 in the meteorites examined. The relative amounts of helium produced separately by primary and secondary radiation were calculated for points along a radius of an iron sphere, of size equal to the probable pre-atmospheric size of "Carbo". Since it is to be expected that the helium-3 to helium-4 ratio will decrease with depth as the mean excitation energy of the iron nuclei decreases[2], the measured values of the ratio $^3He/(^3He + ^4He)$ inside "Carbo" were plotted for the appropriate depths, against the ratio of helium due to primaries to helium due to primaries plus secondaries. The relationship was found to be linear, and, by extrapolating to 100 per cent primary radiation (that is, the value to be expected in a very small meteorite), the ratio of helium-3 to helium-4 was found to be about 0·4; and by extrapolating to 0 per cent primaries (that is, the inside of a very large meteorite, where only secondary radiation is effective) a ratio of about 0·25 was obtained. In "Carbo", at a depth of 29 cm. below the present surface, the observed ratio of helium-3 to helium-4 was 0·277; at this point, the production of helium would already be about 90 per cent due to secondary particles.

It has been pointed out by Bauer[6] that for meteorite samples which were once largely screened from

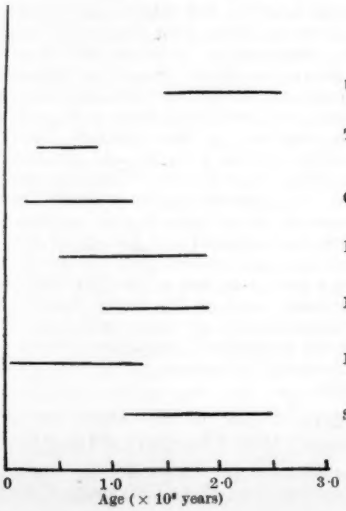
Name	Helium content*	Observed $^3He : ^4He$ ratio	Radiogenic ^4He Ratio 0·40	Radiogenic ^4He Ratio 0·25	Diam. in cm.† (ref. 12)	Type of fall‡ (ref. 12)	Group	Maximum content§ U	Maximum content§ Th	Minimum content§ U	Minimum content§ Th	Ref.
Mount Ayliff	36·8	0·315	6·0	0	14·6	*S*	I	0·58	0·60	0·46	0	9
Tamarugal	23·59	0·309	4·0	0	42	*S*	I	0·34	1·81	0·30	1·39	10
Carbo	22·0	0·286	4·9	0	48	*S*	I	0·60	0·87	0·54	0·49	10
Toluca (Durham)	18·9	0·297	3·8	0	very large	*M*	I	0·70	0·60	0·46	0	9
Sacramento Mts.	11·21	0·3075	2·0	0	38	*S*	I	0·47‖	1·79‖	—	—	11
Arispe	5·32	0·272	1·3	0	35	*M*	I	0·48	1·69	0·44	1·25	10
Bethany Amalia	3·4	0·278	0·84	0	150	*M*	I	0·58	1·55	0·48	0·29	9
San Martin	1·76	0·168	0·87	0·48	—	—	II	0·80	11·8	0·71	9·0	9
Henbury	0·88	0·254	0·25	0·0	very large	*M*	II	1·12	3·38	1·02	2·54	10
Negrillos	0·46	0·190	0·205	0·095	150	*M*	II	0·47‖	1·79‖	—	—	11
Bethany (Harvard)	0·36	0·178	0·17	0·09	150	*M*	II	1·17	1·12	0·58	0·76	10
Coahuila	0·20	0·233	0·068	0·011	132	*M*	II	0·42	0·95	0·38	0·43	10
Toluca (Hamburg)	0·16	0·196	0·070	0·031	very large	*M*	II	0·22	2·65	0·18	2·11	11
Uwet	0·17	0·110	0·114	0·090	23 (?)	*S* (?)	II	0·32	0·68	0·30	0·26	10
Muonionalusta II	0·013	—	—	—	—	*S*	III	0·24	1·1	0·16	0	9
Bethany Lion River	0·002	—	—	—	150	*M*	III	0·29	1·5	0·25	0	11
Muonionalusta I	<0·002	—	—	—	12	*S*	III	1·01	2·79	0·75	0·22	9
Cape York (Ahnighito)	<0·001	—	—	—	220	*M*	III	0·61	1·22	0·13	0·32	9
Cape York (Savik)	<0·0002	—	—	—	220	*M*	III	0·24	0·21	0·16	0	11

* Helium content in 10^{-6} c.c./gm. † Diam. in cm. calculated from recovered masses, assumed spherical. ‡ Type of fall: *M* = multiple, *S* = single. § Uranium and thorium contents in 10^{-6} gm./gm. ‖ Average value for twenty meteorites.

cosmic rays by an outer layer afterwards lost during passage through the atmosphere, the quantity of cosmic-ray helium will be inferior to that produced in small meteorites; in these samples the subtraction of this helium from the total cosmogenic and radiogenic helium can be made with greater certainty than in cases where the bulk of the helium is cosmogenic[1a,4].

In this investigation we have chiefly examined meteorites poor in helium with a ratio of helium-3 to helium-4 less than 0·31. We have assumed, on the grounds stated, that this ratio for helium from cosmic rays is between 0·40 and 0·25, and have thus calculated the radiogenic helium-4 contents. From the uranium and thorium contents, the probable ages have then been evaluated.

Helium was extracted from the meteorites and measured by a method previously described[7], and a mass spectrometric assay made of the helium-3 and helium-4 [8]. The methods of analysis of the uranium and thorium, present to the extent of 10^{-6} gm. per gm. of meteorite, can be found in the references shown in the table. The inherent difficulty in the uranium and thorium estimations, and the uncertainty in the ratio of helium-3 to helium-4, suggest that the age calculations should be made for maximum and minimum values. The maximum spread in age values has been obtained by combining the maximum uranium and thorium values with the value 0·25 for the ratio helium-3 to helium-4, and the minimum uranium and thorium values with the value 0·40 for that ratio. Three results previously published[1a] have been added to this compilation. Results are shown in the table and in the graphical representation of the ages of the Group II meteorites. It appears that the maximum age for this group of meteorites is of the order of a few hundred million years. By a similar method a maximum age of 140×10^6 years for the meteorite Bethany (Harvard) has been deduced previously[1a]. The subtraction method is oversensitive when applied to Group I meteorites.



It should be pointed out that for a meteorite which was originally very large, not only will the cosmogenic helium content be low, but there is also the possibility that the energy of the secondary particles has been reduced to such a value that the ratio of helium-3 to helium-4 is less than 0·25; it is concluded that the lower limits calculated by us are probably more uncertain than the upper limits. Calculations both on the upper and lower limits are difficult in view of the uncertainty about the initial sizes, shapes and velocities of the meteorites.

As insufficient helium for mass spectrometric assay was available from the Group III meteorites, their maximum ages have been calculated on the assumption that all the helium was radiogenic, using the mean uranium and thorium values. The meteorites in this group appear to be much younger than the others. The ages calculated, in million years, are: Savik, 0·4; Ahnighito, 1·1; Muonionalusta I, 1·3; Bethany Lion River, 3·6; Muonionalusta II, 30.

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OBITUARY

Prof. William H. Woglom

Cancer research has suffered the loss of a pioneer, in the death at the age of seventy-four of Prof. William H. Woglom, at the Presbyterian Medical Center, New York, on August 8. Born in Brooklyn, Prof. Woglom graduated in 1901 from the College of Physicians and Surgeons, and after a period in medical practice in Manhattan became assistant in pathology at the Long Island College Hospital, and later pathologist and bacteriologist to the Department of Health. Between 1909 and 1946, at the Crocker Institute of Cancer Research, Columbia University, he was successively assistant, assistant professor, associate professor and professor emeritus, and in 1936 was specially honoured by the University for his conspicuous service. Prof. Woglom was president of the New York Pathological Society during 1924–26, of the American Association for Cancer Research in 1937, and from 1941 until 1946 he acted as a member of the scientific advisory committee of the International Cancer Research Foundation.

In his earlier career Prof. Woglom visited and worked in the laboratories of the Imperial Cancer Research Fund, and this happy association with Britain is reflected in certain joint publications; for example, with J. A. Murray on tar cancer[1], and with B. R. G. Russell on the respiratory exchange of surviving tissues of the mouse[2]. Prof. Woglom was specially devoted to questions of resistance and immunity, and published a paper in this field, on the immune reaction to transplanted cancer in the rat, in the *Proceedings of the Royal Society of London*[3]. Another early paper, of special interest in connexion with later developments in heterotransplantation, discussed tumour inoculation into the eye of an alien species[4]. However, in the list of Prof. Woglom's writings, pride of place should be given to his "The Study of Experimental Cancer: a Review"[5]; remarkable for its time, it still remains a valued classic. In later years he was author of "Discoverers for Medicine", an account of men who, although not physicians, had made important contributions to medicine; and he also translated into English Ernst Cassirer's "Problem of Knowledge" and Charles Oberling's "Riddle of Cancer".

Apart from his scientific accomplishment, mention must be made of other qualities—a generous and kindly nature, high sense of humour (often expressed in telling fashion in his writings and abstracts), extreme fairness and loyalty, and a devotion to literature and music—all of which combined to make him greatly loved by those who had the fortune to know him. He is survived by his widow, and by the children of an earlier marriage. Alex. Haddow

[1] 7th Sci. Rep. Imperial Cancer Research Fund, 1921.
[2] *Brit. J. Exp. Path.*, **1**, 244 (1920).
[3] *Proc. Roy. Soc.*, B, **85**, 197 (1912).
[4] *Proc. Soc. Exp. Biol. Med.*, **12**, 209 (1914/15).
[5] "Studies in Cancer", Vol. 1. Crocker Research Fund, Columbia University (New York, 1913).

NEWS and VIEWS

Vice-Chancellorship of the University of Birmingham: Dr. R. S. Aitken

After Sir Raymond Priestley retired last year from the vice-chancellorship of the University of Birmingham, Prof. H. F. Humphreys, formerly professor of dental surgery in the University, was asked to take over the post until a successor could take office. Although, shortly afterwards, Dr. R. S. Aitken, vice-chancellor of the University of Otago, Dunedin, New Zealand, was appointed to Birmingham, he was unable to take up the post immediately. Prof. Humphreys continued in office for a year until, quite recently, Dr. Aitken was free to take up his new appointment. Dr. Aitken, who was born in New Zealand, was educated at the University of Otago, graduating in medicine and surgery, and then in 1924 gained a Rhodes scholarship to Balliol College, Oxford, where he took a Ph.D. After medical work in the University of London, he was appointed in 1939 as regius professor of medicine in the University of Aberdeen, and it was during the Second World War that his exceptional administrative talents became well known when he took part in a survey of Scottish hospitals. Returning to his native New Zealand in 1948 as vice-chancellor of the University of Otago, Dr. Aitken was faced with the severe task of administering a university which was not only trying to make up for the lost war years but was also rapidly expanding, in keeping with the growing importance of the Antipodes. His services to Otago and also to the Federal University of New Zealand have been profound, and he takes up his duties in Birmingham with a reputation for university administration that is firmly established.

Vice-Chancellorship of the University of Otago, Dunedin: Prof. F. G. Soper, C.B.E.

Dr. R. S. Aitken has been succeeded as vice-chancellor of the University of Otago, Dunedin, by Prof. F. G. Soper, formerly professor of chemistry at Otago. Prof. Soper, who is fifty-five, was educated in Wales at St. Asaph Grammar School and the University College of North Wales, Bangor. After sixteen years as lecturer at Bangor, during which time he gained a D.Sc., he went in 1936 to New Zealand on being appointed professor of chemistry at Otago and shortly afterwards took on the additional responsibility of being director of the New Zealand Woollen Mills Research Association. During the Second World War he served as deputy director of scientific development (chemical) of the New Zealand Department of Scientific and Industrial Research, and he is at present a member of the Defence Science Advisory Committee of that country. As a member of the Academic Board and Senate of the University of New Zealand, Prof. Soper has been closely connected with recent developments in university education in New Zealand and has also given much time to the technical and professional advancement of science, being a past president of the New Zealand Institute of Chemistry and of the Royal Society of New Zealand. Consequently his appointment as vice-chancellor of Otago is singularly apposite and augurs well for the future of the University. He was made a C.B.E. in 1950.

Fisheries Research Vessel *Alister Hardy* of the Fisheries Research Unit, University of Hong Kong

In previous references in *Nature* to the work of the Fisheries Research Unit of the University of Hong

Kong (see *Nature*, **170**, 789 (1952), and **172**, 886 (1953)), mention has been made of the building of a vessel for conducting fisheries research in the waters adjacent to Hong Kong. This vessel was launched on November 7 by Lady Grantham, wife of the Governor of Hong Kong, and was named the *Alister Hardy* in honour of Prof. A. C. Hardy, Linacre professor of zoology in the University of Oxford, who was present at the ceremony. The *Alister Hardy*, although not a large vessel, is one of unusual interest. Into her length of 66 ft. and beam of 17 ft. 10 in. it has been possible, by careful designing and planning, to incorporate all the equipment which will be required by the Fisheries Research Unit for its work at sea. In addition to the usual accommodation for officers and crew, there will be, in the forward part of the vessel, a fully equipped laboratory for scientific work in connexion with the examination and classification of sea life to be carried out immediately the specimens are obtained. To assist in this work there are special desks, provided with illuminated panels, and also a large electric refrigerator with twin compartments; one of these will be set at just above freezing point and the other just below. There will also be a salt-water tank, with circulated water, for keeping specimens alive. The vessel will be propelled by a Crossley diesel engine, developing 130 b.h.p. at 1,350 r.p.m., driving through a gearbox a reversible-pitch propeller manufactured by Messrs. Slack and Parr, both the speed of the engine and the pitch of the propeller being controlled from the wheelhouse; this arrangement is very important, as so often in a diesel-engined vessel it has been found impossible to get a continuous very slow speed which is essential for the successful use of some of the fine plankton-catching nets. As Prof. Hardy remarked in a speech after the launching, nothing is really known of the physics and chemistry of the Hong Kong waters or their fundamental biology—the factors which may be all-important in understanding the lives of the fish: the current systems, the varying saltness of the water, the changing distribution of the small life of the sea, on which the fish feed, and so on; every cruise of the *Alister Hardy* may well be a voyage of discovery.

Expansion of the Department of Scientific and Industrial Research

In reply to questions from Mr. F. Lee and Sir Wavell Wakefield in the House of Commons on December 8, Mr. J. R. Bevins stated that a general understanding which has been reached between the Department of Scientific and Industrial Research and the Treasury provides for the gradual expansion of the Department's activities over the next five years, subject to necessary reservations and the voting of the necessary funds. A programme is envisaged on the basis of which the total resources of the Department should, by 1959, be adequate to cover 95 per cent of the activities projected in the plans covered by the 1947–48 Report, together with some additional responsibilities since taken over from other Departments. Also involved are an increase in staff of a thousand to a total of just more than five thousand, an increase of £900,000, or about 20 per cent of the annual net vote over that period, and a building programme (the cost of which will be borne on the vote of the Ministry of Works) of about £6,000,000. In addition, means will be sought for making good in the plan during later years any deficiencies in expenditure which occurred during the earlier years due to unforeseeable delays in the fulfilment of any planned developments. All estimates of the Department will be presented to Parliament in the usual way.

Higher Technological Education in Great Britain

Regarding the establishment of a College of Technology, on which questions were asked in the House of Commons on December 8, Mr. R. A. Butler stated that, as announced on January 27, the Government proposes to develop higher technological education in London by building up the Imperial College of Science and Technology. Outside London the University Grants Committee has invited universities and colleges on its grant list, which are concerned with higher technological education, to submit their plans for development. When these plans have been received and examined, a further statement will be possible. Meanwhile, Mr. Butler indicated that Manchester is well in the running for a further place, and an institution in Scotland is also envisaged. In reply to Mr. Woodburn, he agreed that these technological institutions could contribute to the development of scientific discoveries in Britain which at present are exploited abroad, but that the technical colleges also could contribute.

In a written reply on December 17 to a question in the House of Commons, Miss Horsbrugh, Minister of Education, stated that the governing bodies of the College of Aeronautics, Cranfield, and the Loughborough College of Technology have each accepted £50,000 to endow a senior teaching post in industrial engineering from the £130,000 allocated for technical education in Counterpart Funds. A sum of £15,000 will be spent in scholarships for persons engaged in industry to enable them to attend courses in work study at these or other suitable educational establishments. While the Minister of Education will be responsible for the disposal of these grants, the Minister of Labour will be responsible for further grants amounting to £15,000, which has been allocated for scholarships in personnel management.

Changes of Outlook in England during the past Hundred Years

On October 23 Lord Samuel gave the Hibbert Lecture in Cambridge marking the centenary of the Trust founded by Robert Hibbert to promote "the spread of Christianity in its most simple and intelligible form" and "the unfettered exercise of the right of private judgment in matters of religion". The Lecture, which was entitled "A Century's Change of Outlook", has been published as a booklet (pp. 22; Cambridge University Press, 1953; 2*s*. 6*d*. net). Lord Samuel surveyed the intellectual, moral, political and economic condition of England a hundred years ago and compared it with the present day. He finds that much has happened of which Hibbert would have approved, though some of the changes have been too rapid for safety, and the prospect of further progress is uncertain. Progress calls for great efforts, above all "to develop a living growing body of thought, at once philosophic, scientific and religious", as a guide to our own and future generations.

United States Federal Research and Development Funds

A further study by the National Science Foundation of the United States Federal Research and

Development Budget for the fiscal years 1952 and 1953 has been published as No. 2 of the series "Federal Funds for Science" (pp. 44. Washington, D.C. : Nat. Sci. Found., 1953). This study, which is based primarily on data supplied to the Foundation by the twenty-four agencies administering such activities, estimates Federal expenditure on scientific research and development in the year ended June 30, 1953, as 2,200 million dollars, an increase of 400 million dollars on the previous year. Commitments were estimated at 2,400 million dollars as against 2,200 million dollars in 1952, but the rate of increase is slackening, and it is expected that both commitments and expenditure will decrease during the fiscal year ending June 30, 1954. It is estimated that about 25 per cent of the expenditure is on work carried out in government-owned installations, 15 per cent on work sponsored at non-profit institutions, and 60 per cent on work sponsored at business organizations. In 1952, twenty-four agencies, and in 1953, twenty-two agencies, administered programmes of research and development, but, of these, seven agencies administered almost 99 per cent of the funds, the Department of Defense accounting for more than 76 per cent and the Atomic Energy Commission for more than 10 per cent of the commitments. Only some 6 per cent of the commitments are for basic research : 121 million dollars in 1952 and 126 million dollars in 1953, 29 per cent of this amount, moreover, being administered by the Atomic Energy Commission. Funds for the physical sciences accounted for 90 per cent out of the total, 7–8 per cent going for work in the biological sciences and the remainder for work in the social sciences. Since 1940, Federal expenditure on research and development has increased more than 22 times, from 97 million dollars to 2,200 millions, the proportion of the Federal budget expended on research and development having also increased, from 1·1 per cent in 1940 to about 3 per cent in 1953.

Medical Research in the United States

The growth of medical research in the United States during 1941–53 and of the role of Public Health Service Research Grants are indicated in a review by K. M. Endicott and E. M. Allen (*Science*, 118, 337 ; 1953). They point out that during the decade 1940–50 expenditure on medical research increased about tenfold, and the Federal Government emerged as a major source of financial support, contributing very little to the total of 18,000,000 dollars in 1941, but 28,000,000 dollars out of 115,000,000 dollars in 1946 and 76 000,000 dollars out of 181,000,000 dollars in 1951. Industry provided 55,000,000 dollars in 1946 and 60,000,000 dollars in 1951. The pool of trained man-power also increased considerably, as did the output of scientific publications. The tendency to concentrate medical research in some dozen large centres was reversed and several powerful new foci of research appeared. The Research Grants Programme of the Public Health Service really began in 1946 with the transfer of fifty projects from the Office of Scientific Research and Development when that agency was dissolved, although the Service had awarded a few grants for cancer research each year since 1937. The new programme had as its objective the improvement of the nation's health through the acquisition of new knowledge in all the sciences related to health, and, in so far as the new knowledge is sought for the purpose of improving health, the programme is one of applied research. However, many of those receiving grants regard their projects as basic, and policies and procedure under the programme have been designed to ensure the maximum freedom to those scientific workers who receive grants. Full freedom of publication is given, and once a grant is made there is no direction or interference on the part of the government. Although in 1951 the Public Health Service research grant programme accounted for only 8·8 per cent of the expenditure on medical research, Endicott and Allen consider that the programme has been of the greatest assistance to institutions able and willing to employ and provide basic facilities for competent scientific workers. Some 35 per cent of the funds, or nearly 35,000,000 dollars, between 1946 and 1953 went on professional assistants to those receiving grants, and many of these assistants themselves now receive grants. Another major effect of the programme has been to stimulate research in neglected fields, particularly research on some of the chronic diseases.

Conflicts of Loyalty

The "Present Question" Conference at Oxford in 1952 on "Conflicts of Loyalties" was concerned with a wider range of problems than its title suggests. The addresses and discussions of most immediate interest to the man of science—those concerned with problems bearing on the conflict of loyalties which may arise out of his professional pursuit of truth and the demands of national security or between religion and science—were reported in the winter 1952 issue of *Question*, which included the papers of H. Westmann on conflicts of loyalties, of Prof. M. Polanyi on science and faith, of Herbert Reid on sign and symbol, and of Dr. J. H. Oldham on man and truth. The remaining papers and discussions, which are given in the spring 1953 issue of *Question* (5, Nos. 2–3 ; pp. 152. London : Hammond, Hammond and Co., Ltd., 1953 ; 7*s.* net), are of much slighter scientific interest, although Angus Maude in his address on morals and politics faces the same issues that Prof. A. V. Hill raised in his presidential address to the British Association shortly afterwards. Generally speaking, these addresses range from the conflicts between the artist's loyalty to the creative impulse and society, between patriotism and world community, between country and party, between functions and personality and between the individual and the family ; generally speaking, they stress the importance of human relations and point to the resolution of the problem of relations between the individual and the family or the group, or the larger units of which industry, society and the international community are built up, as holding the key to the elimination of conflicts of loyalty.

Comparative Studies of Apices

In a recent paper (C. W. Wardlaw : "Comparative Observations on the Shoot Apices of Vascular Plants", *New Phytol.*, 52, 3, 195 ; 1953) it is held that while such new types of histological organization as may be observed in the shoot apices of vascular plants will carry their own interests, the extensive anatomical and histological data which are now available should be studied from the genetical, physiological, physical and mathematical points of view, with the view of discovering the causes underlying the homologies of organization which they show. From a comparative examination of apices, all reproduced at the same magnification, it is inferred that the size and metabolism of the meristem cells of the apex are gene-determined,

but to understand the characteristic histological organization of any apex, both cellular properties and the distribution of growth in the apex as a whole must be considered. Various factors which may affect the histological constitution of the apex, the distinctive character of the apical cell, or apical cell group, in different species, and some geometrical properties of zoned apices are discussed. The tentative conclusion is reached that the homologies of organization, shown by shoot apices at large, may be due more to extrinsic factors and relationships than to genetical factors, although, in fact, both sets of factors work together to produce the observed results.

The Freshwater Biological Association

THE twenty-first annual report of the Freshwater Biological Association contains the usual summary of the scientific work of the staff. Dr. C. H. Mortimer, the hydrologist, has analysed water temperature records from various depths in the two basins of Windermere and confirms that, when compared with wind records, internal waves of a wide range of frequencies are generated during windy weather and die away during calms, but that the wave which is most readily set in motion and persists longest is the single 'see-saw' motion of the thermocline plane. The periodicity of this wave can be calculated for any given example and compared with the periodicities observed, either by inspection of long series of temperature records or, more precisely, by a frequency analysis of them. This comparison has now been extended to ten lakes for which sufficient data exist, ranging in (medial) length and calculated period from 1·5 km. and four hours in the case of the Lunzer Untersee, to 73 km. and four days in the Lake of Geneva.

The algologist, Dr. J. W. G. Lund, has completed a seven-year study of the periodicity of the diatom *Melosira italica*, and shown that this can be related to the occurrence of floods, variations in the amount of light penetrating the water, differences in lake morphology, and water movements, both direct and inverse thermal stratification playing a fundamental part. Moreover, the size of the population in one year may influence that developed in the next. Among work undertaken by other members of the staff was the completion of a survey of the effects of fungal parasitism on the periodicity of plankton diatoms, further investigations into the distribution in lake muds of the two groups of bacteria which reduce sulphates and oxidize thiosulphates, investigation of the morphology of *Desulphovibrio desulphuricans*, marking experiments to determine the details of behaviour of char during the spawning season and an inquiry into the seasonal changes in the activity of the thyroid gland and in the chemical composition of the muscle, liver, gut and gonads of the brown trout.

The Night Sky in January

NEW moon occurs on Jan. 5d. 02h. 21m., U.T., and full moon on Jan. 19d. 02h. 37m. The following conjunctions with the moon take place: Jan. 16d. 01h., Jupiter 4° S.; Jan. 27d. 13h., Saturn 8° N.; Jan. 28d. 15h., Mars 6° N. In addition to these conjunctions with the moon, Mars is in conjunction with Saturn on Jan. 2d. 21h., Mars being 1·3° south. Mercury, a morning star during the first half of the month, is too close to the sun for observation and is in superior conjunction on January 14, after which it is an evening star, setting at 17h. 40m. at the end of the month, about an hour after sunset. Venus, a morning star, is too close to the sun to be observed and is in superior conjunction on January 30. Mars, a morning star, rises at 2h. 50m., 2h. 40m. and 2h. 25m. on January 1, 15 and 31, respectively; its stellar magnitude varies from 1·6 to 1·2, and during the month it moves from a little south of $\varkappa$ Virginis to south of γ Libræ. Jupiter, visible throughout the night, sets in the morning at 6h. 35m., 5h. 30m. and 4h. 20m. at the beginning, middle and end of the month, respectively; stellar magnitude $-2·3$ to $-2·1$; its slow westward movement from near ζ Tauri can be noticed during the month. Saturn is a morning star, its times of rising on January 1, 15 and 31 being 2h. 45m., 1h. 55m. and 0h. 55m., respectively, stellar magnitude 0·8–0·7. Occultations of stars brighter than magnitude 6 are as follows, observation being made at Greenwich: Jan. 2d. 9h. 08·5m., α Scorp. (*D*); Jan. 2d. 10h. 26·6m., α Scorp. (*R*); Jan. 13d. 22h. 23·5m., ε Arie. *m* (*D*); Jan. 14d. 17h. 09·4m., 27 Taur. *m* (*D*); *R* and *D* refer to reappearance and disappearance, respectively. The earth reaches perihelion on Jan. 2d. and the Quadrantic meteors are active on January 2 and 3. On January 5 there will be an annular eclipse of the sun, invisible at Greenwich. During January 18–19 there will be a total eclipse of the moon, the circumstances of the eclipse being as follows:

Moon enters penumbra	Jan. 18d.	23h.	39·6m.
Moon enters umbra	19	00	50·0
Total eclipse begins	19	02	16·6
Middle of eclipse	19	02	31·8
Total eclipse ends	19	02	46·9
Moon leaves umbra	19	04	13·5
Moon leaves penumbra	19	05	24·1

Announcements

THE Institute of Metals has awarded the following Medals for 1954: *Institute of Metals* (*Platinum*) *Medal*, to Dr. Leslie Aitchison, in recognition of his services to metallurgy in industry, in education and in public service; *Rosenhain Medal*, to Prof. A. H. Cottrell, professor of physical metallurgy in the University of Birmingham, in recognition of his outstanding contributions to knowledge in the field of physical metallurgy, with special reference to the deformation of metals.

THE following have been appointed to lectureships in The Queen's University of Belfast: Dr. H. G. Heal (chemistry), Mr. J. G. Stuart (soil mechanics), and Dr. J. Lowy (experimental zoology).

DR. J. F. MCCREA writes: "My attention has been directed by Dr. Alfred Gottschalk to an omission in the final paragraph of my communication, 'Turbidity-reducing Activity of Influenza Virus and Receptor-destroying Enzyme on Sheep Submandibular Mucoid' (*Nature*, **172**, 912; 1953). The sentence referring to the split-products released from mucoproteins after incubation with influenza virus should read: 'An N-substituted fructosamine (*iso*glucosamine) is liberated as an end-product of the interaction between influenza virus and the purified ovomucin or electrophoretically homogeneous urinary mucoprotein substrates (Gottschalk, *Nature*, **167**, 845; 1951)'".

ERRATUM. In the communication "Interstitial Atoms in the Layer Structure $ZnMn_3O_7 3H_2O$ (Chalcophanite)" by A. D. Wadsley (*Nature*, December 12, p. 1103), line 3 should read "$\alpha = 90°$, $\beta = 117·2°$, $\gamma = 120°$".

THE ROYAL SOCIETY OF CANADA

THE Royal Society of Canada held its annual meeting at the University of Western Ontario, London, Ontario, during June 1–3. The scientific sections met separately as is the custom.

Section III (Chemical, Mathematical and Physical Sciences)

The presidential address was presented by Prof. R. L. Jeffery, who described the historical development and the impact of Fourier series on applied and pure mathematics. This was followed by a description of applications of Fourier series in physical problems (W. H. Watson), which together with the presidential address provided an informative and stimulating symposium on a subject of interest to all members of the section.

Following this symposium, the section divided into sub-sections to hear and discuss a total of 122 papers, arranged under the headings of spectroscopy and astrophysics, chemistry, mathematics, nuclear physics, general physics and solid state physics. The papers selected for presentation were not confined by a rigid definition of these headings, and therefore members of the Society were given an excellent review of the main fields of investigation being actively explored at the various research centres across Canada.

Spectroscopy and Astrophysics. This sub-section discussed fifteen papers on molecular spectra, hyperfine structure, Raman spectra, and the interpretation of certain stellar spectra. It included two theoretical papers, one on the calculation of vibrational transition probabilities and the other on the calculation of the dipole moment induced in an H_2–H_2 system during collision.

Chemistry. This sub-section, meeting in two sessions, was presented with twenty-six papers. A group of papers describing the successful synthesis of new series of pyrazolones and metameconine compounds, together with further synthesis of organic deuterium compounds, represented the work in this part of chemistry. Six papers dealt with various aspects of radioactive chemistry, isotopic constitutions and the occurrence of nuclear processes in Nature. Electrochemical studies on resin emulsions, ethyl chloride and the effect of adsorbates on activated carbon were described. The chemical kinetics of gas phase reactions, thermal decomposition, ion exchange and the quenching of resonance radiation were reported. A very complete study of the peats found in Quebec regarded as a potential source of chemical raw materials provided the desirable link with industrial chemistry. A discussion of the orbital valence theory and a description of the motions and interactions of spheres and cylinders suspended in a liquid subjected to a velocity gradient were of particular interest to members of the other sub-sections.

Mathematics. The fourteen papers presented to this sub-section included six presentations of new theorems and properties relating to various topological and function spaces. In particular the theory of L-spaces was considerably extended. Additions to the modular representation theory and the general properties of groups under substitution of formal power series, a discussion of absolute summability functions, hypergeometric functions, and two papers on further generalization of the Laplace transform method gave a sampling of the current interests in pure mathematics. The multiplicity of representations in sets of integers was discussed in two papers. Ordinary physical space received attention when it was shown that a classical theorem is equivalent to the fact that the closest possible packing of equal spheres about lattice points occurs when the centres form the face-centred cubic lattice.

Nuclear Physics. This sub-section received thirty-eight reports, of which twenty-six were read at its two sessions, and the remaining thirteen reported by title. The wide variety of techniques and reactions used, nuclei studied and properties measured preclude any convenient classification of the papers.

The results of cosmic ray studies were reported in four papers while two others presented problems of particle identification in photographic emulsions. Descriptions of new technical advances included an apparatus for the observation of spin echoes, the stabilization of a Van de Graaff generator, a single-crystal scintillation spectrometer, a three-crystal pair spectrometer, coincidence circuits with resolving time of $\sim 10^{-11}$ sec. and an improved beta-ray spectrometer.

A description of neutron diffraction in liquid oxygen, nitrogen and argon, the successful testing of a new method of nuclear spin determination and five theoretical papers on coupling, resonance, spin and magnetic moment calculations completed the programme of this sub-section.

General Physics. Of the twelve papers presented to this sub-section, eight dealt with radio physics problems: radio investigation of the aurora, solar noise, design of filters, effect of matching on crystal parameters, microwave diffraction and microwave spectroscopy. Members were shown that the thickness of irregularly shaped particles determined by shadow-casting methods is not necessarily accurate. Three papers were reported by title.

Solid State Physics. The fourteen papers presented to this sub-section included all those devoted to low-temperature theory and problems; four on studies concerned with liquid helium, two on superconductivity, paramagnetic resonance and thermoelectricity. Other theoretical papers described an alternative solution to the Ehrenfest problem, the effect of assumed anharmonicity in the classical linear chain with nearest-neighbour interaction, the reverse saturation current of germanium rectifiers, the self-consistent field of Au^+, and the relation of vapour density to snow crystal type. Reports on the tensile strength of liquid nitrogen and observations of the pattern of snow trails in seeded showers were given.

A. D. Misener

Section IV (Geological Sciences)

The twenty-one papers given before Section IV included most branches of the geological sciences. J. T. Wilson discussed the earth as a heat engine, and its operation under the laws of physics; J. A. Jacobs reviewed the composition of the core of the earth and how it could have become solid through loss of heat by convection, though only conduction appears necessary. Some characteristics of grabens, rifts, major wrench faults and straight island chains, their agreement with E. M. Anderson's explanation of wrench faults and their occurrences were discussed by J. T. Wilson. H. S. Heaps gave a theoretical analysis of 'downpunching', with the stresses produced in the outer crust of the earth by the weight of a cylinder on its surface, and showed that some of the results apply to the load imposed by an ice cap. The interpretation of structural features, seen in aerial photographs of south-eastern Ontario, was discussed by A. Burlinson. E. S. Moore gave an account of the structural history of the Porcupine Gold area revealed by detailed mapping.

Two papers described glacial features mapped from aerial photographs in the vast territories of the north and their interpretation, that by M. J. Downie, A. G. Evans and J. T. Wilson dealt with the region between the Mackenzie River and Hudson Bay, while that by M. C. V. Douglas and R. N. Drummond covered Ungava.

Three papers were devoted to the determination of the ages of rocks: first, an account of the branching ratio of potassium-40 by R. D. Russell, H. A. Shilliber and A. K. Mousuf; second, the determination of the ages of lead ores from their isotopic constitutions, by R. M. Farquhar, R. D. Russell and J. T. Wilson; and third, the isotopic constitution of the Sudbury galenas, by R. D. Russell, R. M. Farquhar and G. L. Cumming. J. F. Henderson gave a new and more complete explanation of the formation of pillow lavas and breccias of the Precambrian Shield. M. E. Wilson described the pre-Timiskaming unconformity in the Rouyn–Beauchastel area. C. Faessler described the surface alteration of some ore deposits from Montmagny and Bellechasse counties, Quebec, and some rare minerals from them. The origin and structure of the pyritic ore-bodies of Algoma, east of Goudreau, and their connexion with the Algoma granite, were discussed by G. V. Douglas. An account of the origin of the Nova Scotian gypsum and anhydrite deposits was given by N. R. Goodman.

The paper by H. V. Warren, R. E. Delauvault and D. G. Routley described the detection of traces of molybdenum in vegetation growing where the rocks contain the metal. A. R. Byers demonstrated that the Missi Series of the Amisk Lake area, northern Saskatchewan, was probably laid down during the folding of the underlying rocks. A paper of great importance in Precambrian geology was that by J. E. Thomson. This paper shakes the foundation of present conceptions of the Precambrian stratigraphy in the region west of Sudbury, which has long been regarded as a type and classical section of the Precambrian in North America. It focuses a critical light upon the past work in the region, and offers constructive ideas as to how the problems raised may be tackled. F. F. Osborne described a peculiar concretion conglomerate in the Charny sandstone and discussed its origin. L. S. Russell described the discovery of a new freshwater fauna, including terrestrial gastropods and small mammalian forms, and showed that it dates the Kishenehn formation of south-eastern British Columbia as uppermost Eocene and necessitates some revision of ideas on the history of the southern Rocky Mountains of Canada. H. S. Bostock

Section V (Biological Sciences)

W. A. Clemen's presidential address on "Some Fundamental Problems in the Biology of Pacific Salmon" dealt with the systematics, phylogeny, distribution and migrations of *Oncorhynchus*. In discussing migration, the author referred particularly to endocrine and associated behaviour-pattern changes in relation to cyclic environmental factors. E. G. D. Murray's Flavelle medallist's address "The Story of Listeria" indicated problems in comparative pathology, physiology, biochemistry of lipids and histogenesis of mononuclear leucocytes arising from the discovery of a bacterial disease characterized by monocytosis, focal necrosis and œdema, occurring on all continents and in nineteen animal species (including man) in various somewhat species-restricted forms without differentiation of the causative bacterium. Three other papers were also delivered at the first general session. "On the Nutritional Requirements of Young Children", by T. Allen, A. V. MacLeod and E. G. Young, reported conclusions from two surveys comprising 156 children 1–6 years of age, in which nutrition assessed from physical, anthropometric, laboratory and radiographic observations was correlated with dietary consumption of essential nutrients. P. Dansereau discussed "Interpretation of the Post-glacial Pine Period in Eastern North America". He considered alternative hypotheses, respectively attributing stages of abundant *Pinus* pollen during this epoch to environmental factors and to adaptation of the prevalent species, and then reviewed the evidence provided in six specific instances, by geology, climatology, evolution, genetics, taxonomy, ecology and sociology. Finally, W. Radforth, in "The Use of Plant Materials in Recognizing Northern Organic Terrain Types", described microfossil studies combined with form analyses of associated living vegetation as aids in the accurate classification of terrain for ground and air mapping.

The second general session consisted of a symposium on "Recent Approaches to the Control of Diseases and Pests in Plant and Animal Life". H. Martin reviewed chemical contributions resulting from the discovery and delimitation (particularly in respect of mammalian toxicity) of biological activity in synthetic compounds, exemplified by DDT and 2 : 4-D. J. M. Cameron discussed the variable results achieved in forest insect control by chemicals and by biological methods, utilizing sylviculture, parasites and predators. F. B. Hutt illustrated the importance of genetic differences in resistance of animals (including man) to infection, and their relation to the control of specific diseases. E. G. D. Murray selectively reviewed recent advances in medical bacteriology, indicating some findings of general biological significance. He also suggested lines of fruitful investigation, such as determination of the specific cellular functions affected by antibiotics.

In a short summary, reference can be made to only a few of the more specialized papers presented at the meetings of sub-sections. In botany and zoology, G. N. Irvine, W. Bushuk and J. A. Anderson reported first-order reaction kinetics for crude

catalase extracts from wheat which, unlike the crystalline enzyme, were not activated by the hydrogen peroxide substrate. P. V. Vittorio and G. Krotkov discussed the synthesis of sucrose and starch in detached tobacco leaves infiltrated with carbon-14-labelled glucose and glucose-1-phosphate. They concluded that the fructose moiety of sucrose arose from infiltrating glucose and not from free fructose, but that infiltrated radioactive sugars contributed only a small amount of their activity to starch.

D. E. Wells reported the discovery of *Ascocybe*, a new genus of primitive *Ascomycetes*, as a common saprophyte on wood, while M. Raymond described a noteworthy new hybrid between *Eriophorum angustifolium* and *E. chamissonis*. L. Butler summarized the results of an experiment with large and small strains of mice involving inbreeding and selection to increase the size of the former strain and decrease that of the latter. No effect of inbreeding on vigour was noted. In the large strain, experimental selection was neutralized by opposed effects of natural selection. In the small strain effects of natural selection were dominant, and body-size actually increased in each generation.

In physiology and medical sciences, W. R. Campbell described a new method of photometric estimation of serum calcium, based on Schwarzenbach's reaction and promising routine rapidity and precision. E. T. English and R. L. Noble demonstrated that although either periodic acid or an aqueous extract of *Lithospermum corceum* may induce inactivation of human chorionic gonadotrophin *in vitro*, the mode of inactivation differs when judged by histological examination of the ovaries of treated animals. W. H. Cook and C. V. Luzena discussed ice propagation in model systems of solutions and membranes, in relation to the ability of living cells to survive freezing. Discontinuous behaviour is favoured by low membrane porosity, rapid cooling and increased concentration of solutes in the aqueous phase; supercooling and nucleation ahead of the ice front can be demonstrated in sucrose and gelatin solutions. C. A. Mitchell presented data indicating that at least two viruses can propagate themselves within the bovine mammary gland; resulting locally produced neutralizing antibodies may be found in both the blood and milk serum. J. Tuba and M. I. Robinson reported that rat intestinal alkaline phosphatase consists of an adaptive portion varying with the dietary state and a non-adaptive fraction remaining constant even during prolonged fasting; the former is probably translocated lymphatically during fat absorption, thus elevating serum phosphatase levels. A. H. Hutchinson, V. H. Turnbridge and M. Elvin submitted photomicrographic evidence for mitosis, syngamy and meiosis in *Bacillus subtilis* (the cytological cycle being completed in two hours at 40° C.), and compared the observed structural detail of euchromatic progression with the cytology of other forms.

N. H. Grace
J. W. Hopkins

New Fellows

Six new fellows were elected to Section III: G. A. Adams, H. J. Bernstein, I. Halperin, M. Kulka, M. S. Macphail, J. S. Marshall; four to Section IV: N. Campbell, Y. O. Fortier, J. W. Watson, L. J. Weeks; and six to Section V: J. A. Dauphinee, C. C. Heimburger, A. G. McCalla, J. H. Orr, J. H. Quastel, E. H. Strickland.

PHOTOELECTRIC RAINDROP SPECTROMETER

DETERMINATION of the frequency distribution of the diameter of raindrops in relation to the rate of rainfall is an important problem of meteorological measurement. Knowledge of this distribution is important in the major scientific problem of the formation of raindrops and in such practical matters as protection of aircraft from ice accretion. Several methods have been used hitherto, such as measuring the size of the pellets formed when the drops fall into fine flour, the diameter of splashes on filter paper, or the magnitude of the noise produced when the drop hits a microphone. All had serious disadvantages, such as uncertainty of calibration or lack of flexibility in use in natural rain in which the rate of fall sometimes changes quickly.

Now, in the October number of the *Quarterly Journal of the Royal Meteorological Society*, B. J. Mason and R. Ramanadham, of the Department of Meteorology, Imperial College of Science and Technology, London, describe an entirely new apparatus—the photoelectric raindrop spectrometer—which is based on the scattering of light by the drops. A parallel beam of light of horizontal axis is produced, and the drops falling through a rhombus-shaped section in this beam of area 72 cm.^{2} scatter light into the cathode of a photo-multiplier cell. The voltage produced by the light pulse is suitably amplified and recorded and the results interpreted from calibration with drops of known size. The apparatus has the great advantage that it records continuously and takes account without difficulty of obliquely falling drops and of changes in the rate of fall. The probability of two drops falling through the area in natural rain at the same time to give overlapping impulses on the recorder is so small that it can be entirely neglected.

A comparison of this new apparatus with older, more clumsy methods has shown very good agreement. A few records are given in the paper. A series taken during showers shows that the drop – frequency curve had two modes in the heavier rain. The rates of fall varied from 2·43 mm./hr. to 0·22 mm./hr. All had a mode of drop-diameter at 0·9 mm.; the 0·22 mm./hr. rain had no second mode, and the second modes were 1·4 mm. for the rate of 0·66 mm./hr., and 1·6 mm. for the rates of 1·26 and 2·43 mm./hr. The amount of rainfall recorded by a rainfall recorder over several minutes during a light shower and the amount deduced from the spectrometer readings agreed to within 5 per cent. The raindrop spectrometer is to be used in conjunction with a 3-cm. radar in the study of condensation processes.

NATIONAL CENTRAL LIBRARY LONDON

REPORT FOR 1952–53

THE thirty-seventh annual report of the executive committee of the National Central Library, London, covering the year ended February 28, 1953, records an increase in the Treasury grant-in-aid from £27,250 during 1951–52 to £31,250. The funds at the Trustees' disposal were insufficient to cover the cost of the essential reinforcements in the east wing of

the building. The Carnegie United Kingdom Trust, when appealed to, made a special grant of £7,500, as well as one of £750, towards the survey of the regional library systems and the National Central Library.

A joint working party, the terms of reference of which were expanded to include further aspects of inter-library lending, completed its work during the year, and its report was received by the executive committee in 1952, when the recommendations were submitted forthwith to the regional library executive committees for comment. A sub-committee of the joint standing committee on library co-operation has undertaken a project under which certain university and other libraries have agreed to co-operate, by purchases within certain periods of years, in filling gaps in British secondary or 'background' literature which is in increasing danger of being sold abroad. Returns have been made of several thousand holdings in many of the greater public libraries and university libraries.

Compared with 1951–52, issues of books from or through the Library increased by 1,105 to 99,413, issues through university libraries and special outlier libraries increasing from 16,997 and 9,798, respectively, to 18,040 and 10,198, while those through municipal libraries and industrial and research organizations decreased, from 26,569 and 5,828 to 23,630 and 5,746, respectively. Total applications decreased slightly (from 101,383 to 100,049), but the percentage of applications handled successfully increased from 68·27 to 71·21. Issues from the Scottish Central Library increased from 15,708 to 16,349 and from the Irish Central Library for Students from 12,089 to 12,450. Outlier libraries now number 225 and lent 24,478 volumes during the year. Books supplied by the regional system to other libraries in their own regions generally decreased, but university libraries, apart from loans under the national system, lent 23,905 books to other libraries during the year, compared with 21,965 during 1951–52. International loans also increased: 2,154 books were lent to 38, and 1,026 books borrowed from 21, countries. Progress is also reported in the National Union Catalogue and the Union Catalogue of Russian Books and Periodicals, and the Sheaf Catalogue for German War-Time Books was completed.

FORESTS OF THE BELGIAN CONGO

UNDER the title of "Forest Species and Timbers of the Congo" the Institut National pour l'Étude Agronomique du Congo Belge is publishing a monograph of which the first part has now appeared*. This part, which is an introduction to a study of the botanic and forest characteristics of species of the Congo forests, points out that Belgian forests alone can only supply a little more than half her timber requirements; and as they are chiefly conifers they cannot provide for such necessities as construction and furniture, etc. Belgium has therefore to depend, in the same way as Britain, largely upon foreign markets, Scandinavian and United States, for the rest of her requirements. This has brought to the notice of a section of the public and to the Belgium Government that the Belgian Congo is one of the countries which possess the greatest areas of dense forests on the globe; for all the central part of the Belgian Congo is covered with the great equatorial forests of Central Africa, and these are estimated to amount to 125 million hectares, consisting of the diversity of species found in mixed tropical forests and representing, says the monograph, milliards of cubic metres of timber.

At first sight it would be asked why has this great source of timber wealth not been already drawn upon? The answer, it is stated—and the British began to discover this for the tropical forests more than a century ago in India—is found in the inaccessibility of the forests, difficulties of exploitation, extraction and transport; but a start has been made. As was also found in India, there are difficulties in introducing new tropical timbers on the world markets, conservative timber merchants, architects and other users of timber being against such new importations.

The first question posed, however, is the necessity of knowing the botanic contents of the forests; and the second, whether a timber species of marketable value exists in sufficient abundance in a section of the forest to make its exploitation a commercial success. Also, as Bertin, a French forest officer of considerable African experience in the Ivory Coast and elsewhere during the First World War and after, said in his "La Question Forestière Coloniale" (Paris, Larose, 1919): "Impossible de s'intéresser à des bois dont on ignore même le nom". It is considered, and probably correctly, that the Congo forests are not enough to provide for all the requirements of Belgium both in quantity and quality.

This monograph is being prepared with that object in view. It has the double purpose, botanic and forest, and will provide in subsequent parts a botanic and physical description of each species dealt with, followed by the mechanical and technological properties of the timber. In fact, much of it is on the lines of Gamble's "Manual of Indian Timbers" first published in the latter part of last century. This first part of the Belgian monograph is confined to general principles only. E. P. STEBBING

* Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Essences Forestière et Bois du Congo: Fascicule 1, Introduction. By Jean Louis and Joseph Fouarge. Pp. 72+15 plates. (Brussels, 1953.) 180 Belg. francs.

MOTOR RESPONSES EVOKED BY THE DORSAL OCELLI OF *SARCOPHAGA ALDRICHI* PARKER, AND THE ORIENTATION OF THE FLY TO PLANE POLARIZED LIGHT

By DR. W. G. WELLINGTON

Forest Insect Laboratory, Sault Ste. Marie, Ontario

IT has been suggested that the dorsal ocelli of adult insects are only stimulatory organs, capable of increasing any response to stimuli received through the compound eyes, but incapable of evoking a motor response by themselves[1,2]. Behaviour studies that support this view include those in which bees[3] or ants[4] acted as though blind when only their ocelli were uncovered, and those in which bees[3] and *Drosophila*[5] reacted more rapidly to sudden variations in light intensity when their ocelli, as well as their compound eyes, were uncovered.

Adult ocelli vary in complexity, and Wigglesworth[6] has pointed out that their function may not

be the same in all insects. Adults of many species, however, have ocelli that are quite similar to the lateral ocelli of the larvæ of tenthredinid sawflies—insects that certainly exhibit motor responses to light. Consequently, it has never been completely clear why adult ocelli of this type should not evoke similar reflex movements quite independently of any evoked by the compound eyes.

At the low temperatures (20–23° C.) and low light intensities commonly used in laboratory tests of light reactions, larvæ of the *Neodiprion* sawflies orientate themselves much less precisely to a point source than they do to intensity gradients from the unobstructed sky outdoors. Even outdoors, however, they seldom maintain as steady directions of travel as lepidopterous larvæ that have several stemmata more widely distributed over the sides of the head. These facts suggest that the type of response evoked by adult ocelli might also be influenced by several factors. Therefore, it seemed worth while to test some adult insects outdoors as well as indoors, so that the effects of natural light from the sky could be observed.

The species used was *Sarcophaga aldrichi* Parker, a common dipterous parasite. At ordinary room temperatures, the fly is strongly photopositive, and either crawls or flies directly towards a light when released. Clipping the wings does not alter this response, so this was done to keep specimens from escaping during outdoor tests. Flies tested were always freshly collected outdoors, since it was found that they did not survive prolonged storage at room temperature, and that those stored at lower temperatures for more than a few hours could not withstand the high surface temperatures when they were taken outside again. Blackboard paint was used to cover the ocelli or the compound eyes. The surface of the paint was always checked for cracks after each test, to guard against discrepancies produced by exposure of a few ommatidia.

Fig. 1 shows examples of the types of tracks obtained. Tracks *A*–*E* show the responses to a 6-watt panel lamp resting on a table in a darkened room. Tracks *A′*–*E′* show the movements of the same individuals on cardboard on the ground outdoors. The lines on the tracks indicate 10-sec. intervals.

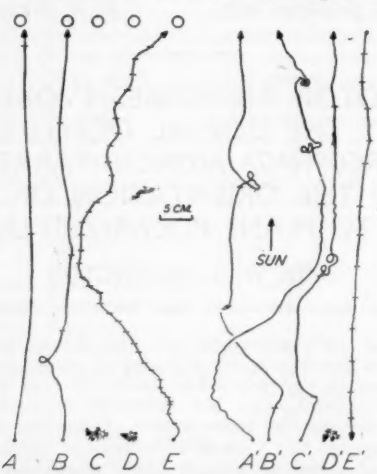

Fig. 1. Responses of *Sarcophaga* and a *Neodiprion* larva to light indoors and outdoors. Tracks *A*–*E*: movements in a darkened room with a 6-watt lamp in the position shown. *A*: a fly with all its eyes uncovered; *B*: a fly with only its compound eyes uncovered; *C*: a fly with only its ocelli uncovered; *D*: a fly with all its eyes covered; *E*: a fourth-instar larva of *Neodiprion sertifer* (Geoff.). Tracks *A′*–*E′*: movements of the same individuals over the ground outdoors. Time-marks on all tracks show 10-sec. intervals

In the indoor group, track *A* shows the path of a fly with all its eyes intact, whereas track *B* shows the movements of a fly with only its compound eyes functioning. In *B*, the slower response is evident. Track *C* shows the small amount of undirected movement that occurred when only the ocelli were uncovered, and track *D* shows the result of covering all the eyes. Track *E* shows the path of a fourth-instar larva of *Neodiprion sertifer* (Geoff.).

In the outdoor group, the tracks of moving insects showed some orientation with respect to the sun, the direction of which is indicated. The important difference between this and the former series is shown in *C′*, the path of the fly with only its ocelli uncovered. Clearly, the movements were as directed as any made by flies with more eyes functioning.

Track *D′*, the path of the fly with all its eyes painted, was still similar to *D*, indoors. Such a small amount of undirected movement outdoors occurs only when blind flies are not too hot. When they are overheated, they move more; but, in the absence of wind, their movements are still relatively undirected. When there is a gentle breeze, the blind flies can travel in relatively straight lines away from the sun.

The flies that made the tracks *A′*–*D′* were all cool, but the sawfly larva (*E′*) was tested later in the day, and was hot enough to move directly away from the sun[7]. The irregularities shown in tracks *A′*–*C′* were produced by responses to patches of cirrus cloud or smoke passing overhead, and do not occur when the sky is clear. The sawfly was tested when there was only haze, so that its track was straight, in striking contrast to *E*, indoors.

It has already been shown that larvæ of various species, including those of the sawfly, *N. banksianæ* Roh., respond to rotation of the axis of a sheet of 'Polaroid' while they are crawling on the ground[7]. This is a similar response to that originally described by von Frisch in bees[8], and observed more recently in other types of adult insects[9], in mosquito larvæ[10], and in other arthropods[10,11]. Fig. 2 shows examples of responses of adults of *S. aldrichi* and of a larva of *N. sertifer* to 'Polaroid' rotation while the insects were travelling on the ground.

The circles and their accompanying pointers beside each track in Fig. 2 show the points at which a sheet of 'Polaroid' was placed over the moving insect, or rotated, or withdrawn. The bars within the circles indicate the orientation of the axis of the 'Polaroid' with respect to the sun, and the black circles indicate that the sky appeared appreciably darker when the axis was orientated as shown. It can be seen that maximum darkening usually occurred when the axis pointed towards the sun, not at right angles to it, and that orientation of the axis towards the sun generally resulted in a change in the direction of travel. The exception is discussed in sequence below.

Track *A* shows the path of a fly with all its eyes functioning. The first two turns in this track are examples of a relatively rare response that has been observed at least once in each species tested to date—a change in direction sometimes amounting to nearly 180° in response to a 90° rotation of the 'Polaroid' axis—but the sky conditions associated with it are still not fully understood. The remaining

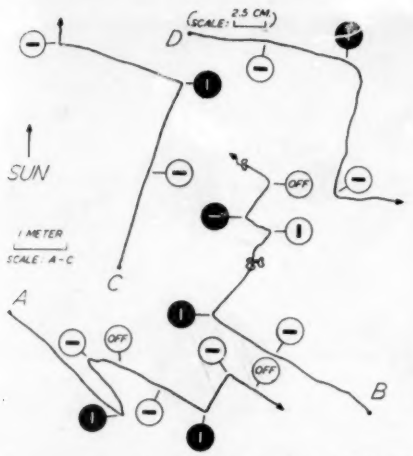

Fig. 2. Effects of rotation of the axis of a sheet of 'Polaroid' on the direction of travel of *Sarcophaga* and of a *Neodiprion* larva crawling over the ground. Circles show the points at which the sheet of 'Polaroid' was placed over a moving insect, or rotated, or withdrawn. The bars inside the circles show the orientation of the axis with respect to the sun, and the colour of the circle indicates whether or not the sky was appreciably darkened when viewed through the 'Polaroid' with the axis set as shown. Track *A*: a fly with all its eyes functional; *B*: a fly with only its compound eyes uncovered; *C*: a fly with only its ocelli uncovered; *D*: a fourth-instar larva of *Neodiprion sertifer* (Geoff.)

directional changes are of the type most often observed when the axis is turned through 90°, and are the expected responses to the axis directions shown. (Turns are often extremely sharp, within one to five body-lengths; but, occasionally, a smoother, slower turn is made that does not show well at reduced scale.)

Track *B* shows the path of a fly with only its compound eyes uncovered. The marked convolutions in the path about one metre after the first response to rotation occurred when a patch of cirrus passed overhead. Irregularities in the path continued to appear as additional wisps of cloud followed the first patch and, finally, at the point marked by the second white circle, a larger cirrus cloud produced a steady change in polarization, and the insect returned to its original heading. It maintained this heading until the axis was rotated to the position that had previously produced no response under a clear sky, but this time the response was obtained under the cloud. Such changes in the direction of travel associated with changes in polarization are common occurrences under smoke, cirrus and, occasionally, haze[7], and sometimes make it impossible to obtain reproducible results, especially near large industrial centres.

Track *C* shows the responses of a fly with only its ocelli functioning, and track *D*, on a different scale, shows the path of a fourth-instar larva of *N. sertifer*. It is clear that the ocelli of the adult sarcophagid are as sensitive to changes in the polarized light from the sky as are those of the sawfly larva.

The foregoing results show that the dorsal ocelli of adults of *S. aldrichi* are quite capable of evoking motor responses by themselves. Moreover, movements that flies with only ocelli make outdoors are just as directed as those made by flies that have all their eyes intact. In fact, only two really consistent differences were observed outdoors between flies with functional compound eyes and those with only ocelli. First, those with compound eyes were easily startled by movements of the observer, whereas those with only ocelli were indifferent to all but the most obvious and rapid changes in light intensity produced by these movements. Secondly, when clouds covered both the sun and the zenith, intact adults seldom stopped moving, whereas those with only ocelli invariably stopped until the sun reappeared; and, even then, they made only undirected movements until the overhead sky cleared again. In short, these flies behaved more like larvæ than like adults. [Aug. 5.

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HEXAMITA MELEAGRIDIS

By D. SLAVIN and J. E. WILSON

Ministry of Agriculture and Fisheries Veterinary Laboratory, Lasswade, Midlothian

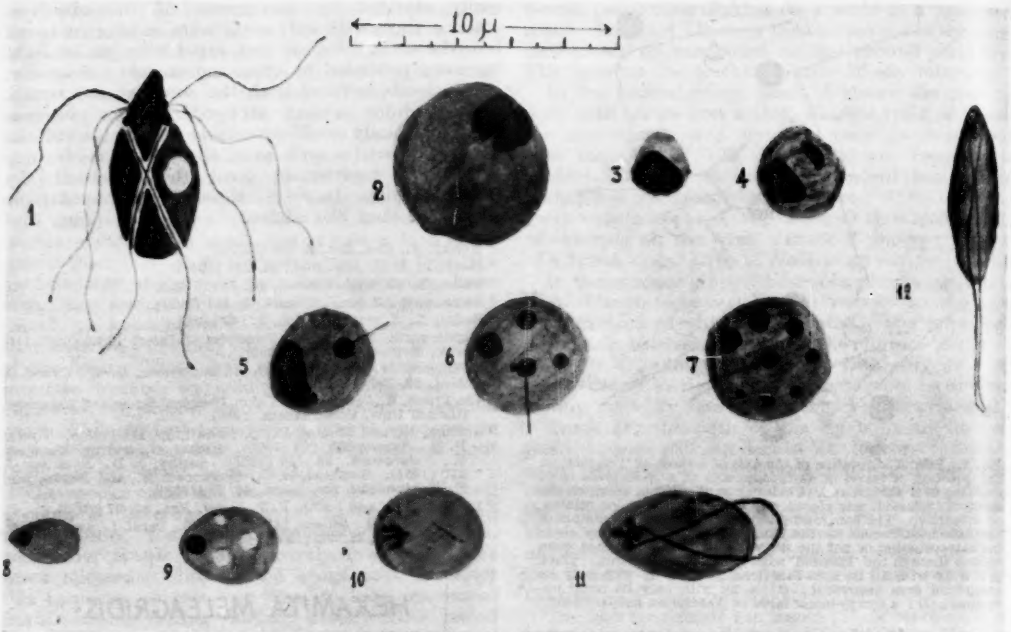
IT was shown by Hinshaw, McNeil and Kofoid[1] and by Hinshaw and McNeil[2] that a serious enteric disease of turkeys in the United States of America is caused by a protozoan parasite which they named *Hexamita meleagridis*. A description of its morphology was later given by these authors[3].

In the course of investigating several serious outbreaks of the disease in Great Britain, an extensive systematic study of the life-cycle of the causal parasite was made; our results differ in certain respects from those already reported. As they revealed some hitherto unrecorded information which may assist in a better understanding of the epidemiology of the disease, they are considered to be worth publishing.

Because of certain morphological resemblances to *Giardia* and *Hexamita muris*, *Hexamita meleagridis* has been assumed to reproduce by simple binary fission, one flagellate producing two, and so on. The present work has shown this to be erroneous, and has clearly demonstrated the reproductive cycle in the reticulo-endothelial cells and tissue interspaces of the bowel wall. The most heavily invaded sites are the villi of the small intestine, excepting those of the duodenum. After innumerable examinations of stained smears by standard microscopic means and of wet preparations by phase contrast, no dividing flagellates have ever been seen.

The life-cycle as found here is briefly as follows: the development of a binucleate cyst from the mature flagellate (Fig. 1), production of invasive forms from these cysts, probably by breaking free of the nuclear structures, invasion of reticulo-endothelial cells and tissue interspaces with formation of schizonts and merozoites, which finally develop into mature flagellates.

Cysts. The easiest method of demonstrating cysts was to wash out the bowel of heavily infected birds



Figs. (1) The mature flagellate. (2) A forty-eight-hour old cyst. (3 and 4) The earliest invasive forms seen 24 hr. after experimental infection. (5, 6 and 7) Various types of schizont; in each case the blue body has a line pointing to it. (8, 9 and 10) Development stages of the merozoite. (11) Early motile intracellular form of *Hexamita* as seen under phase contrast. (12) The tadpole form as seen under phase contrast

with 10 per cent serum broth, allow the gross matter to sediment, and concentrate the mature flagellates by centrifugation. The heavy suspension of flagellates was then incubated at 37° C., and within two hours a high proportion had encysted. Encystment under a sealed coverslip was also observed by phase contrast. The fully developed cyst (Fig. 2) is quite round, about 6·0 μ in diameter, and has a double nucleus to one side. Some of the flagella may be retained for days after encystment. The development of the invasive form from the cyst has not been completely traced, as not many of our experimentally infected birds were destroyed for examination within 24–48 hr. after exposure, but the earliest forms seen at 24 hr. are as in Fig. 3. They are about 1·5–2·0 μ in diameter, have very dense chromatin with acidophil cytoplasm and probably arise in twos by simple freeing of the nuclear structures of the cysts. Some of these early forms may show double chromatin structures (as in Fig. 4) or even treble ones, but the chromatin is always unevenly divided and always dense.

Schizogony cycle. The earliest schizont is a round pale pinkish-staining structure with a large dense chromatin body to one side and always a smaller round blue body at the other side, as in Fig. 5. The blue body may or may not have a number of small dense chromatin dots (up to eight have been counted in some), and appears to play an essential part in the division of the chromatin of the schizont. Sometimes, as in Fig. 6, a small chromatin dot is seen closely attached to the blue body, and it is not clear at present whether the chromatin structures of the schizonts are extruded by the blue body or whether the blue body simply initiates division of the chromatin already present in the schizont. The latter seems the more likely process, as in schizonts with only one chromatin mass this is always large and in schizonts with several chromatin bodies these are always smaller. Whatever the process involved, the final picture is as in Fig. 7. This shows a characteristic schizont with seven chromatin bodies (the highest number we have seen) and the central blue body. A constant feature of these schizonts is the inequality of division of the chromatin and its density, and the presence of the blue body.

The subsequent development of the flagellate from the schizont is not clear, but examinations so far indicate that the chromatin bodies break up into merozoites about 1·0 μ in length and similar to that shown in Fig. 8, as in sick birds killed before the appearance of flagellates in the intestine there have been noted groups of three to four small merozoites. One schizont has actually been photographed showing this break-up of a chromatin body, but it has not been illustrated here as there is still some doubt of the reproductive process at this stage. The development process in Figs. 8–12 and in Fig. 1 have been clearly traced. The merozoite in Fig. 8 is a little more than 2·0 μ long, with bluish homogeneous cytoplasm and a dense purple-staining round nucleus. As this enlarges, its cytoplasm stains more faintly and a few vacuoles develop as in Fig. 9. Then the nucleus breaks up and primitive development of the posterior flagellum commences as in Fig. 10. Further development is seen in Fig. 11. When parasites at this stage are examined under phase contrast, they appear to be in an envelope. They are sluggishly motile and progress by waving the tail membrane containing the primitive posterior flagellum and by sending undulations down the sides of the body. This indicates that they already possess primitive anterior flagella enclosed in a membrane or still within the body of the parasite although they have not been illustrated here. The next stage is the tadpole form (Fig. 12) and this precedes the mature

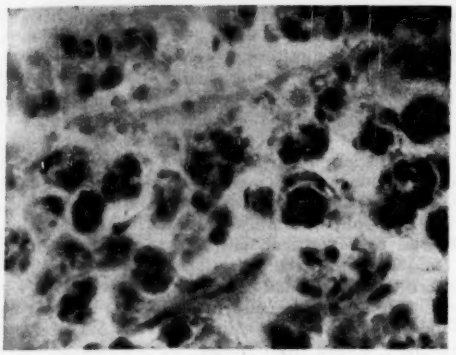


Fig. 13. Cross-section of a villus of small intestine, stained haematoxylin × 1,000. The upper portion of the photograph shows the epithelium of the villus. Beneath this is the basement membrane, and throughout the rest of the photograph can be seen reticulo-endothelial cells packed with development forms of the parasite, probably the stages of Figs. 9, 10 and 11

flagellate. It is about the same size as the mature flagellate and has a long streaming membrane enclosing the posterior flagellum. It is rather gracefully motile in contrast to the active zigzag movement of the mature flagellate and proceeds by waving the posterior membrane and sending undulations down the body. The anterior flagella are probably present at this stage also but enclosed within the body of the parasite or under a covering membrane. Both Figs. 11 and 12 were drawn from phase-contrast examination, and although this method shows up a good deal of internal structure, it has never been possible to see the anterior flagellum of the tadpole forms.

When the parasite has developed motile forms in the reticulo-endothelial cells of the villi, they make their way through the epithelium into the lumen of the bowel and immediately go down into the glands to feed and mature. In sections of bowel from heavily infected birds, the reticulo-endothelial cells of the villi are packed with developing forms of the parasite (Fig. 13), while the glands are packed with flagellates. These two factors suffice to make the disease a most difficult one to treat, as an effective therapeutic agent would have to destroy the developing forms of the parasite in the reticulo-endothelial cells of the villi or kill the mature parasites deep in the glands. Most of the established antiprotozoal drugs have been tried here on artificially infected poults, and none was found which effectively did either. Few had even any action *in vitro*, but liquid 'Entramin' killed within minutes. Birds given it in drinking water had a higher rate of survival than untreated birds, as a proportion of the parasites were killed when they entered the lumen of the bowel. The initial development of the parasite in a new host is directed towards establishment of a population, and when birds first show symptoms of illness the schizogony cycle is well advanced and the foundations laid for further severe progress of the disease. The therapeutic agent of choice would therefore be one which killed the developing forms in the bowel wall.

As it was not possible to watch the actual development of each form of the parasite into the succeeding one by tissue culture or by examination of material from birds killed at set intervals after artificial infection, some gaps in the life-cycle have had to be filled in deductively. These are the development of invasive forms from the cysts and of merozoites from the schizonts. However, it is felt that further study will prove the deductions made on these stages to be substantially correct.

Hexamitiasis is a deadly disease, and the main bulk of the present work was directed towards finding an effective curative agent; when once the salient points in the life-cycle had been uncovered, not many birds were slaughtered solely for more detailed study of the developmental stages.

A number of *Hexamita muris* from white rats was examined both under phase contrast and in stained smears. The morphology was found to be as stated by Wenyon[4]. Apart from some resemblance in shape and the possession of six anterior and two posterior flagella, there was nothing to indicate any relationship between this flagellate and *Hexamita meleagridis*, and the two will eventually have to be placed in separate genera.

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'ADENOSINE TRIPHOSPHATE–CREATINE TRANSPHOSPHORYLASE' AS RELAXING FACTOR OF MUSCLE

By Dr. L. LORAND
Institute for Muscle Research, Marine Biological Laboratory, Woods Hole, Massachusetts

THE recently published work of Goodall and A. G. Szent-Györgyi[1] clearly showed that—apart from certain ionic requirements—there are at least two factors in muscle jointly concerned with relaxing the adenosine triphosphate-induced tension of glycerinated fibres. They discovered that one of these is phosphocreatine and the other was shown to be a heat-labile, non-dialysable component that could be obtained from muscle by extraction with 0·05 *M* sodium bicarbonate. This second principle, called *X*-factor, was presumed to be a protein (or several proteins), and it was also inferred that it may turn out to be an enzyme for which phosphocreatine is a substrate. The present communication reports the identification of this relaxing protein component of muscle, showing that it is 'adenosine triphosphate–creatine transphosphorylase', catalysing the reaction:

$$\text{phosphocreatine} + \text{ADP} \rightleftharpoons \text{creatine} + \text{ATP}.$$

Muscle fibres. For test material, bundles of muscle fibres were cut out from rabbit psoas and washed with 50 per cent (v/v) glycerol at 0° C. for 24 hr., according to A. Szent-Györgyi[2]. The fibres were then treated for five days at − 20° C. with 50 per cent (v/v) glycerol containing 0·05 *M* sodium bicarbonate. According to Goodall and A. G. Szent-Györgyi[1], this additional treatment washes out all relaxing factors from the fibres. Indeed, this was borne out by the control runs, an example of which is shown in Fig. 1. After treatment for five days, the fibres were stored in 50 per cent (v/v) glycerol at − 20° C.

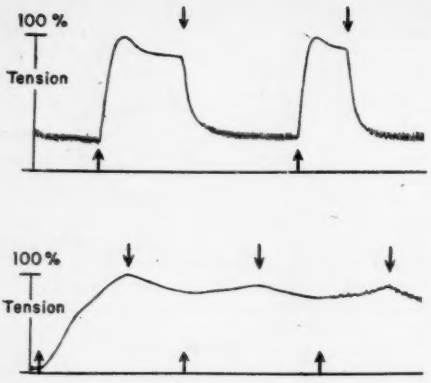

Fig. 1. Upper curve: Effect of alternating the *p*H in the presence of muscle extract
Lower curve: The effect of alternating the *p*H in the absence of muscle extract. Adenosine triphosphate, phosphocreatine, magnesium ions, potassium ions present (control run)
↑ = fibre immersed in neutral bath; ↓ = fibre immersed in *p*H 6·2 bath

Testing the relaxing activity of muscle fractions. Procedures were identical with those described by Goodall and A. G. Szent-Györgyi[1], and the tests were carried out at room temperature. The fibres were incubated in the test solution for 15 min. prior to mounting in the isometric tension recorder designed by Goodall. Both baths, in which the fibre is immersed alternately, contain test fluid of identical composition: 0·3 ml. 0·05 *M* sodium adenosine triphosphate, 0·3 ml. 0·1 *M* sodium phosphocreatine, and 2·4 ml. of the muscle fraction to be tested dissolved in 0·1 *M* potassium chloride and 0·001 *M* magnesium chloride. Nitrogen is bubbled through one of the baths, thereby maintaining a *p*H around neutrality (*p*H 7·2), while carbon dioxide is passed through the other, establishing a somewhat more acidic *p*H (around *p*H 6·2). If foaming is excessive, a drop of capryl alcohol may be added. Tension develops when the fibre is immersed in the neutral bath. It can be seen in Fig. 1 that tension develops much faster in the system where muscle extract is present, together with adenosine triphosphate and phosphocreatine, than in the control where only the two latter substances are available. This clearly indicates that muscle contains a factor that accelerates the development of tension. The same observation was made earlier by Goodall and A. G. Szent-Györgyi[1], who also found that as regards the speed of attaining full tension the addition of a small amount of a neutral solution of cysteine has the same effect as muscle extract.

Full tension will persist as long as the fibre is kept in the neutral medium; but as soon as the bath is changed for the more acidic one, the tension falls abruptly if the relaxing factor is present. In the absence of this factor, acidification results only in a slow and small drop in tension, as shown in Fig. 1.

By placing the glycerinated fibre, in the presence of magnesium ions, potassium ions, adenosine triphosphate, phosphocreatine and the relaxing factor, alternately in the neutral and the acidic bath, the fibre can be carried through cycles of tension and relaxation as many times as the *p*H is changed. The *p*H dependence of tension in this system served as a useful assay in isolating the relaxing factor. The percentage drop in tension when the fibre is placed in the bath of lower *p*H may be taken as a quantitative sign of the relaxing activity of the medium. The quantitative evaluation of relaxing activity in the rigorous sense may be somewhat uncertain, because it is difficult to know for certain that the penetration of the relaxing factor into the fibre and its distribution within is complete and uniform all the time. In spite of these uncertainties, if a physico-chemically homogeneous substance could be isolated that would cause relaxation when applied in small concentrations, it would be highly probable that the isolated material was identical with the relaxing factor.

Isolation and characterization of the relaxing factor. Since its outset, it has been the purpose of this work to decide whether enzymes that phosphorylate adenosine diphosphate would act as relaxing factor. Therefore, initial fractionation of the muscle extract was so directed that isolation steps were included from Banga's description[3] for preparing 'adenosine triphosphate–creatine phosphopherase'. Enzyme activity was determined by the procedure used by Banga; this consists of measuring phosphocreatine (as 'easily hydrolysable' phosphate by the method of Fiske and SubbaRow[4]) produced in the presence of the enzyme from adenosine triphosphate and creatine. It was found that preparations active as enzymes would also cause relaxation of the glycerinated fibre. At this point it was of utmost help that a newly devised method was made available by Kuby, Noda and Lardy[5] for purifying 'adenosine triphosphate–creatine transphosphorylase'. This purification results in an enzyme preparation that is homogeneous in the ultracentrifuge and the electrophoresis apparatus. I am greatly indebted to Dr. H. A. Lardy for hitherto unpublished details of the method of enzyme isolation that run briefly as follows[5].

"Rabbit skeletal muscle is extracted with 0·01 *M* potassium chloride and the extract is fractionated in the following steps: (1) Heat denaturation of inert proteins at 40° C. (2) Fractionation at − 10° C. in the presence of 0·1 *M* magnesium acetate at *p*H 6·5, between 52 and 67 per cent (v/v) of 95 per cent ethanol. (3) Denaturation of inert proteins at 20° C., *p*H 8·5, 60 per cent (v/v) of 95 per cent ethanol, and precipitation of the protein magnesium salts at 20° C. in 60 per cent (v/v) of 95 per cent ethanol, 0·03 *M* magnesium sulphate at *p*H 8·5, followed by fractional extraction with 0·07 *M* magnesium sulphate, *p*H 9·0 at 0° C. (4) Fractionation at 0° C. in the presence of 0·1 *M* manganese acetate, *p*H 6·8, between 56·6 and 65 per cent (v/v) of 95 per cent ethanol. (5) Precipitation of the enzyme at 0° C. in 0·02 *M* sodium chloride, 0·005 *M* zinc acetate, *p*H 7·0, 34 per cent (v/v) of 95 per cent ethanol."

During the course of the isolation of the enzyme, the various fractions were tested for relaxing activity, thereby obtaining an estimate of the yield and degree of purification of the relaxing factor. A typical example may be cited. It was found that the supernatant of fraction 1 caused a 60 per cent drop of tension. Fraction 2 did the same when made up to the volume of the supernatant of fraction 1. Also, a 60 per cent drop of tension was obtained with fraction 4 when made up to about two-thirds, and with fraction 5 when made up to about half the volume of the supernatant of fraction 1. This implies that about 50–60 per cent of the total relaxing activity present in the supernatant of fraction 1 can be recovered in the final fraction. At the same time, the total protein content of the supernatant of fraction 1

was found to be 36–50 times greater than that of fraction 5. Thus, from the point of view of relaxing activity, a purification of 18–30 fold has been achieved between fractions 1 and 5. Since the yield and degree of purification of 'adenosine triphosphate–creatine transphosphorylase' obtained by the procedure is of the same order of magnitude[5], it is obvious that the purification of the enzyme results in a similar purification of the relaxing factor.

To corroborate the suggestion that the enzyme and relaxing factor may be the same substance, a final check was made using an enzyme preparation of Drs. S. A. Kuby and L. Noda and kindly given to us by Dr. H. A. Lardy. The assays of these workers showed that the preparation had the highest activity obtainable for 'adenosine triphosphate–creatine transphosphorylase', and the preparation was homogeneous by electrophoresis under a wide variety of experimental conditions, in the ultracentrifuge and also by solubility tests. This enzyme preparation was highly potent when tested for relaxing activity, and Fig. 2 shows an example of its effect when used in a concentration of about 0·3 mgm./ml.

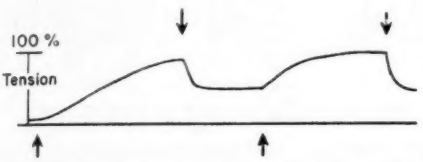

Fig. 2. Tension-relaxation cycles of glycerinated fibre in the presence of magnesium ions, potassium ions, adenosine triphosphate, phosphocreatine and pure 'adenosine triphosphate–creatine transphosphorylase'
↑ = fibre immersed in neutral bath; ↓ = fibre immersed in *p*H 6·2 bath

Discussion. It has been shown that glycerinated fibres (representing the contractile element of muscle) can be carried through full activity cycles of tension and relaxation when immersed in a solution composed of pure substances. Since all constituents of the medium are used in physiological concentrations, it would appear that the development of tension and subsequent relaxation proceeds also in living muscle by the same mechanism. When glycerinated fibres are in a solution containing potassium ions, magnesium ions, adenosine triphosphate, phosphocreatine and pure 'adenosine triphosphate–creatine transphosphorylase', alteration in the *p*H from about *p*H 7·0 to about *p*H 6·0 can initiate the activity cycle: neutral *p*H favours contraction, and the lower *p*H relaxation. It has been shown[6] that such *p*H changes can occur in the intact muscle fibre. Moreover, according to Dubuisson[7], relaxation is associated with an increase in *p*H, which again points to the possibility that an alternating change of *p*H inside the muscle fibre may be the actual 'trigger' for initiating contraction and relaxation. The recent work of Bozler[8] and Goodall and A. G. Szent-Györgyi[1] showed that small amounts of calcium ions may have an equally important part in initiating the activity cycle: the presence of calcium ions favours contraction, their absence enhances relaxation. In the living muscle, *p*H and concentration of calcium ions may turn out to be independent or complementary parameters in controlling the activity cycle.

'Adenosine triphosphate–creatine transphosphorylase' has been suspected by several workers to be involved in the relaxation of muscle; the present work is the first definite proof to that effect. It has been shown that phosphocreatine facilitates relaxation only in association with the enzyme. Thus it seems that relaxation means rephosphorylation of adenosine diphosphate bound to the contractile proteins. In such a picture, the state of muscle when contraction is initiated would correspond to ATP·$_{AM}$ ('AM' index signifies that the nucleotide is bound to actomyosin) and to ADP·$_{AM}$ when contraction is complete. If during contraction the protein-bound adenosine triphosphate is dephosphorylated, relaxation can be described as follows:

$$\text{Phosphocreatine} + \text{ADP}\cdot_{AM} \xrightarrow{\text{transphosphorylase}} \text{creatine} + \text{ATP}\cdot_{AM}.$$

Future experiments may show that systems that can produce adenosine triphosphate (such as the phosphocreatine plus 'adenosine triphosphate–creatine transphosphorylase' system) have an effect on purified actomyosin similar to that on the relaxation of the glycerinated fibre. In this connexion, it is interesting to recall some experiments of Laki (personal communication). He noticed an apparent volume increase of the myosin *B* 'superprecipitate' in the presence of creatine, magnesium ions and dialysed muscle extract. (It is conceivable that appreciable amounts of phosphocreatine were formed in this system that were responsible for the observed effect.)

The relaxation of muscle fibre being equivalent to rephosphorylating the adenosine diphosphate bound to the proteins, it is to be expected that, besides 'adenosine triphosphate–creatine transphosphorylase', other enzymes, too, that can produce adenosine triphosphate from the diphosphate, would facilitate the relaxation of the muscle fibre. Such a potentially active substance would be myokinase, which produces adenosine triphosphate by dismutation of two adenosine diphosphate molecules. One would expect, however, such systems to work more slowly in producing relaxation, and therefore they would only be of secondary importance from the physiological point of view as compared with the phosphocreatine and 'adenosine triphosphate–creatine transphosphorylase' system. The relaxing factor described by Marsh[9] has recently been proved to be a protein[10]; when isolated, it may turn out to be identical with the transphosphorylase discussed in the present work, or it may be another enzyme producing adenosine triphosphate, such as, for example, myokinase.

I wish to thank Mr. M. C. Goodall and Dr. Andrew G. Szent-Györgyi for their help and Mr. P. Neal for his enthusiastic work. My thanks are also due to Prof. Albert Szent-Györgyi for the benefit of discussions.

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LETTERS TO THE EDITORS

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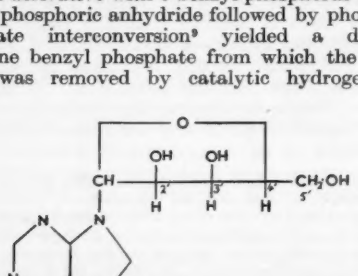
Structure of Adenylic Acids a and *b*

With the demonstration[1] that the main internucleotidic linkage in ribonucleic acids is *b* : 5′, it is clear that a final decision between 2′ : 5′ and 3′ : 5′ as possible linkage positions[2] can be reached by determining the location of the phosphoryl group in the isomeric *a* and *b* nucleotides obtained by alkaline hydrolysis of ribonucleic acids[3]. Brown and Todd[4] showed that these nucleotides are the 2′- and 3′-phosphates of the corresponding nucleosides, although not necessarily respectively.

Indirect evidence[5] of a physical nature has been advanced for the view that cytidylic acid *b* is cytidine-3′-phosphate; this evidence, which would also indicate[6] that uridylic acid *b* is uridine-3′-phosphate, is plausible but scarcely decisive. More direct evidence[7] has been provided in the case of the isomeric adenylic acids; hydrolysis of the isomers with an acid ion-exchange resin followed by study of the mixture of phosphorylated ribose derivatives so obtained indicated with some probability that the adenylic acids *a* and *b* were respectively the 2′- and 3′-phosphates of adenosine (I). This conclusion, although probably warranted, suffers from the defect that it rests on arguments concerning the relative speeds of phosphoryl migration and hydrolysis during contact with the ion-exchange resin used. The problem of providing rigid and unambiguous proof of structure thus remains, and we have attacked it in the case of the isomeric adenylic acids using both chemical and physical methods.

The difficulty which besets any chemical method of structural determination is the ease with which phosphoryl migration occurs in the *a* and *b* nucleotides; the free acids undergo migration in acid, although not in alkaline, media, while their esters are labile both under acid and alkaline conditions[2,4]. Clearly no chemical proof of structure can be valid if it involves group migration at any stage. Thus the application of the classical methylation procedure employed for structural determination in the carbohydrate series is of no value, since phosphoryl migration occurs during methylation[8]. We were able to surmount the difficulty in the following way.

Partial acetylation of 5′-acetyladenosine yielded only one 0 : 0-diacetyladenosine. Treatment of this diacetyl derivative with 0-benzyl phosphorus 0 : 0-diphenyl phosphoric anhydride followed by phosphite–phosphate interconversion[9] yielded a diacetyladenosine benzyl phosphate from which the benzyl group was removed by catalytic hydrogenation.



(I)

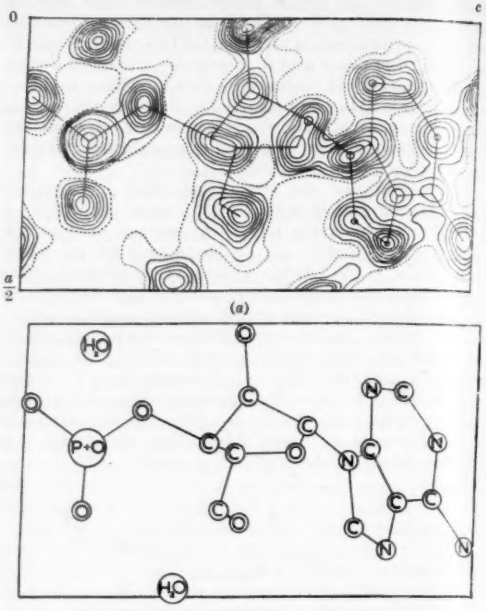


Fig. 1. Calculated electron density for adenylic acid *b* projected on (010). Contours at 1*e*.A.$^{-1}$ interval with dashed contour 2*e*.A.$^{-1}$. The dotted contours around the overlapped phosphorus and oxygen are at 5, 10, 15, 20 and 25 *e*.A.$^{-1}$

Gentle alkaline hydrolysis of the diacetyladenosine phosphate prepared in this way removed the acetyl groups and yielded adenylic acid *a* alone and uncontaminated by any of the *b* isomer. Since *only* the *a* isomer was obtained, it is clear that no phosphoryl migration could have occurred at any stage and hence the diacetyladenosine used must have been *b* : 5′-diacetyladenosine. The *b* : 5′-diacetyladenosine was now treated with toluene-*p*-sulphonyl chloride, yielding *b* : 5′-diacetyl-*a*-tosyladenosine. Methanolysis of this product under conditions which do not cause migration of the tosyl group gave adenine and a methyl tosyl-D-ribofuranoside. The latter was separated, methylated and hydrolysed; the sole dimethylribofuranose obtained in this way was identified as 3 : 5-dimethylribofuranose. It follows that the original tosylated diacetyladenosine was 3′ : 5′-diacetyl-2′-tosyladenosine, and hence that adenylic acid *a* is adenosine-2′-phosphate.

Parallel with these studies we have also made a direct determination of the structure of adenylic acid *b* by X-ray crystallographic methods. This nucleotide crystallizes as colourless needles with an estimated 1·5 molecules of water for each molecule of acid[4]. Oscillation and Weissenberg photographs gave the unit cell data as:

$a = 10{\cdot}06$ A.; $b = 6{\cdot}30$ A.; $c = 11{\cdot}84$ A.; $\beta = 92{\cdot}5°$ and space group $P2_1$.

Intensities of the X-ray reflexions were visually estimated for the (*h*0*l*) zone and the projection of the structure on (010) was determined. Figs. 1*a* and 1*b* show a Fourier synthesis of the electron density on this plane and the appearance of the projected molecule. This clearly shows the position of the phosphate residue and establishes the *b* acid as the 3′-phosphate.

The investigation is being continued for the purpose of finding the stereochemistry of the molecule, bond-lengths and angles, disposition of hydrogen bonds, etc., in more detail, and when this has been done a full description of the structure and the method of structure analysis employed will be published by one of us (M. M. W.).

D. M. Brown
G. D. Fasman
D. I. Magrath
A. R. Todd
University Chemical Laboratory,
Cambridge.

W. Cochran
M. M. Woolfson
Cavendish Laboratory,
Cambridge.
Nov. 4.

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Conversion of δ-Aminolævulinic Acid to Porphobilinogen in a Tissue System

We showed recently[1] that porphobilinogen is a highly specific precursor of porphyrins, and Shemin and Russell[2] have presented evidence that δ-aminolævulinic acid is a specific precursor of hæm. Shemin and Russell's finding has been confirmed independently in our system (cf. Neuberger and Scott[3]) to the extent that, on incubation with a chicken red cell hæmolysate[4], δ-aminolævulinic acid is converted to uro-, copro- and protoporphyrins. The yield of each of these porphyrins from δ-aminolævulinic acid was, moreover, identical to that[1] from an equivalent amount of porphobilinogen. The structure of porphobilinogen[5] suggests that this compound could be formed by the condensation of two molecules of δ-aminolævulinic acid (see also refs. 2 and 3), and the equivalence of the two compounds with respect to porphyrin formation may be taken as support for this idea. We now present evidence indicating the occurrence of such a condensation in the chicken red cell hæmolysate.

When δ-aminolævulinic acid is incubated with the hæmolysate, a substance reacting positively with Ehrlich's reagent can be shown to accumulate. After paper chromatography of this material in either a butanol – acetic acid or a phenol – ammonia solvent system[6], only one spot reacting with Ehrlich's reagent was found. With both solvent systems the R_F values and appearance of the spots were identical to those obtained with a crystalline sample of porphobilinogen hydrochloride. The material was concentrated[6]; on heating the resulting solution in acid[6], a porphyrin was obtained which, on paper chromatograms, behaved identically to the uroporphyrin obtained in the same way from pure porphobilinogen[5]. Furthermore, conversion to substances behaving on paper chromatograms as the acetyl and lactam derivatives[5] of porphobilinogen was demonstrated. We therefore believe that the material formed from δ-aminolævulinic acid in the hæmolysate is, in fact, porphobilinogen.

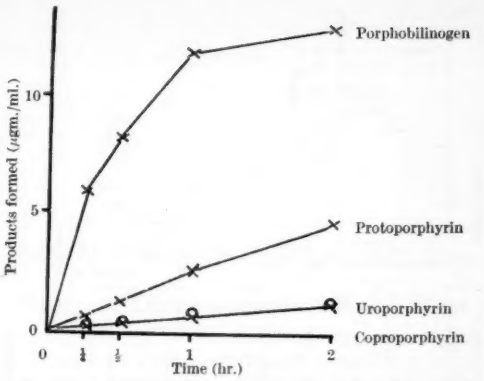

Fig. 1. Conversion of δ-aminolævulinic acid to porphobilinogen and porphyrins. Hæmolysate (ref. 4) incubated at 38°, with shaking in air. δ-Aminolævulinic acid added, 47 μgm./ml.

The accumulation of porphobilinogen, uro-, copro- and protoporphyrins in a hæmolysate incubated with δ-aminolævulinic acid is illustrated in Fig. 1. No trace of these substances was formed if the hæmolysate was boiled prior to the addition of δ-aminolævulinic acid.

We are continuing our study of the interconversions of the porphyrins and their precursors, and, in particular, the relation of these processes to the biosynthesis of hæm.

We thank Mr. J. J. Scott and Dr. A. Neuberger for a gift of δ-aminolævulinic acid, Miss A. Benson for her assistance and Prof. C. Rimington for his continuing support.

E. I. B. Dresel
J. E. Falk
Nuffield Unit for the Investigation of
Pyrrole Pigment Metabolism,
Department of Chemical Pathology,
University College Hospital Medical School,
London, W.C.1.
Dec. 1.

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Chromatographic Behaviour of Intermedin as determined by *in vitro* Assays

Paper chromatography was used in a recent attempt to obtain purified intermedin, the melanophorotropic hormone of the pituitary intermediate lobe. This communication is submitted because of the new assays employed and the interesting chromatographic behaviour of intermedin activity.

Powdered hog posterior pituitary glands were treated by the method of Landgrebe, Reid and

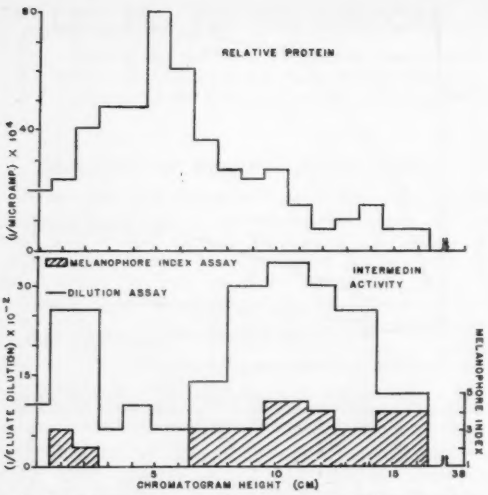

Fig. 1. Intermedin activity and protein concentrations on paper chromatogram

Waring[1] for the preparation of potentiated intermedin. The precipitate obtained was dissolved in distilled water and the resulting solution was applied in a series of adjacent 5-μl. drops forming a horizontal band near the bottom of a sheet of Whatman No. 1 filter paper. The band was built up by superimposed drops until 17·5 mgm. of pituitary material had been deposited. The chromatogram was developed in ascending fashion at room temperature with solvents consisting of the upper layer of a mixture by volume of 4 parts water, 4 parts *n*-butanol and 1 part acetic acid.

When the solvent front had ascended 38 cm. from the line along which the pituitary material had been applied, the chromatogram was dried, and 1·0-cm. wide vertical strips from each side were sprayed with ammoniacal silver nitrate and 0·2 per cent ninhydrin in water-saturated butanol. No reducing carbohydrates were detected. After the ninhydrin-positive areas had developed for several days, the strips were moved 1·0 cm. at a time past a 1·0-cm.[2] opening in black paper masking the surface of a General Electric barrier-layer photo cell which was connected to a microammeter, and upon which was focused a microscope lamp. By plotting vertical distance up the chromatogram against reciprocal of ammeter reading minus reciprocal of ammeter reading when filter paper with nothing adsorbed to it was held over the photo cell, a crude estimate of the relative amounts of ninhydrin-positive material as a function of chromatogram height was obtained.

The chromatogram was cut into a series of horizontal strips and the adsorbed material from each strip was eluted in 1·0 ml. of distilled water per mm. of chromatogram height.

Eluates were assayed for intermedin activity by their effect on melanophores in the excised web of the foot of *Rana pipiens*. Webs were washed in amphibian Ringer solution until all melanophores were punctate, and cut into squares with areas of 1·0 mm.[2] or less which were placed in depression slides. The measure of eluate activity was the reciprocal of the maximum dilution in millilitres of eluate per millilitre of Ringer which caused the melanophores to attain a stellate stage of pigment dispersion in 1 hr. Mixtures of eluates gave values that were averages of individual values.

Another assay technique depended on the observation that rate of pigment concentration after removal of intermedin was inversely proportional to the hormone concentration to which the melanophores were exposed. Web squares were immersed in 0·002 ml. of eluate per ml. of Ringer for 2 hr., at which time all melanophores were reticulate. The squares were then transferred to Ringer solution which was changed every 20 min. Two hours after transfer to Ringer solution, melanophore indices[2] of the web melanophores were noted.

Fig. 1 shows that intermedin activity exists in two concentration peaks: one associated with a small ninhydrin-positive peak with an R_F value of 0·28, the other with a ninhydrin-positive area with an R_F value of 0·04. The question of whether intermedin activity exists in two different molecules or in a molecule which adsorbs to different substances was not investigated.

The investigation of which this procedure was a part was undertaken during tenure of a National Science Foundation Fellowship.

Robert R. Kohn

Department of Zoology,
University of Michigan,
Ann Arbor.
Sept. 15.

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The Fries Reaction

In continuation of the study of the mechanism of the Fries reaction[1], a systematic investigation of the effect of medium on the rearrangement of phenyl (I; R=H)- and *p*-cresyl(I; R=CH_3)-hydrogen succinate in presence of anhydrous aluminium chloride has been carried out. The reaction was accomplished under standardized conditions using a constant temperature (117°, boiling *n*-butyl alcohol bath) for 2½ hr., the same molecular proportion of the ester (0·033 mole), aluminium chloride (0·067 mole) and the solvent (0·462 mole). The results are summarized in Table 1.

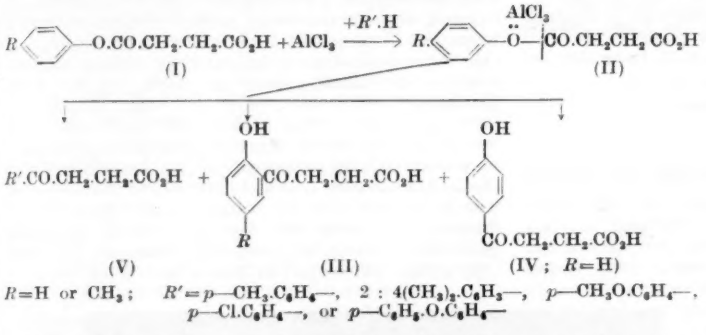
The results showed that, whereas phenyl hydrogen succinate, when heated with aluminium chloride in acetylene tetrachloride or nitrobenzene, gave a mixture of III (R=H) and IV, *p*-cresyl hydrogen succinate gave only III (R=CH_3)[2]. The structure of the latter acid (III; R=CH_3) was inferred from the fact that it was not etherified by diazomethane in absence of methyl alcohol[3], and that it gives a violet colour with ferric chloride[2,4]. When the reaction was carried out in a solvent the molecules of which contain *o*-, *p*-directing groups (that is, they are susceptible to the attack of electrophilic reagents) such as toluene, *m*-xylene, anisole, diphenyl ether and chlorobenzene, the oxo-carbonium ions[1], $\overset{+}{C}O.CH_2.CH_2.COOH$, combine with the solvent to give a non-phenolic β-aroyl propionic acid (V). The method adopted for the separation of the acids III, IV (as its ethyl ester), and V was based on esterifying the mixture with ethyl alcohol and hydrogen chloride, then extracting III and IV with sodium hydroxide solution. III (R=H) and IV were separated by diazomethane[1].

Table 1

Solvent	μ	I; R = H (6·53 gm.)				I; R = CH_3 (7 gm.)	
		Mix. of III (R = H) + IV*	III (R = H)†	IV†	V†	III (R = CH_3)†	V†
Acetylene tetrachloride	0	5·3 gm.	3·8 gm.	trace	—	4·6 gm.	—
Nitrobenzene	4·96	3·2	0·83	0·38	—	3·9‡	—
Toluene	0·37	1·7	1·55	trace	0·9	1·27	1·11
m-Xylene	0·4	1·0	0·76	trace	3·1	0·30‡	2·68
Anisole§	1·2	—	—	—	1·98	—	2·25
Diphenyl ether	1·17	0·5	0·25	trace	5·16	—	3·80
Chlorobenzene	1·54	2·8	2·70	trace	0·55	2·65	0·63

* Crude. † Crystallized once and identified by melting point and mixed melting point with authentic specimens. ‡ Weight of the crude product, which was crystallized several times for purification. § Results not reliable since anisole was demethylated with aluminium chloride

The results showed also that, in the reaction with phenyl hydrogen succinate, the ratio of the *p*-hydroxy-acid (IV) increased with the increase in the dipole moment of the solvent[5] (cf. acetylene tetrachloride and nitrobenzene, Table 1).



R=H or CH_3; R' = *p*—$CH_3.C_6H_4$—, 2 : 4$(CH_3)_2.C_6H_3$—, *p*—$CH_3O.C_6H_4$—, *p*—ClC_6H_4—, or *p*—$C_6H_5.O.C_6H_4$—

The yields of the β-aroyl propionic acids (V) increased by the increase in the nucleophilic character of the solvent[6], and it was least in the case of chlorobenzene. This supports the previous assumption by Baddar and El-Assal[1] that the formation of IV and V takes place by an electrophilic attack of the ion $\overset{+}{C}O.CH_2.CH_2.CO_2H$ on the phenoxide – aluminium chloride complex and the solvent molecules, respectively[7].

It appears, therefore, that the ratio of *ortho* to *para* in the Fries reaction, using aluminium chloride, depends upon the nature of the ester and the ease of formation of the oxo-carbonium ion, on the dielectic constant of the solvent, and on the temperature of the reaction[8].

The investigation is being extended to *o*-, *m*-cresyl- and naphthyl-hydrogen succinates.

Abdel Fattah Marey
Fawzy G. Baddar
William I. Awad

Faculty of Science,
Cairo University, Giza,
and Ibrahim University,
Abbassia, Egypt.
Sept. 1.

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Thiamine Triphosphate in Bakers' Yeast

In earlier work on cocarboxylase (thiamine diphosphate) as a phosphate carrier, an unknown spot was often found, not reported in the previous publication[1], when extracts from liver were chromatographed in order to isolate thiamine diphosphate from other phosphate compounds. This unknown spot gave, like thiamine diphosphate, a blue fluorescence in ultra-violet light after having been oxidized with potassium ferricyanide in alkaline solution. It also, like thiamine diphosphate, had biological activity when tested in a Warburg apparatus with washed yeast. In 1949 Velluz *et al.*[2] reported their work on synthetic thiamine phosphate, thiamine triphosphate, and its relation to thiamine diphosphate. When comparing this compound on a chromatogram with the unknown compound referred to above, I found them to behave in exactly the same manner. At the same time Rossi-Fanelli *et al.*[3] confirmed the occurrence of thiamine triphosphate in rat liver.

To be able, however, to study the mutual relations between thiamine tri- and diphosphate, and especially the synthesis of the two compounds from thiamine, I needed a system in which thiamine could be phosphorylated in greater amounts than in liver. According to Sperber and Renvall[4], bakers' yeast possesses the capacity of phosphorylating added thiamine to a rather large extent in the presence of glucose. Taking advantage of this, I obtained a yeast extract rich in thiamine phosphates. After a crude purification, the thiamine phosphates and remaining thiamine were chromatographed according to the method of Kiessling and Lindahl[5]. The results are shown in Fig. 1.

Fig. 1. *E*: Chromatogram of an extract from bakers' yeast in which thiamine has been partially phosphorylated. *K*: Chromatogram of a mixture of thiamine and synthetic thiamine phosphates. *Thi*: Chromatogram of a thiamine solution. (*TTP* = thiamine triphosphate; *TDP* = thiamine diphosphate; *TMP* = thiamine monophosphate; *T* = thiamine)

The compounds are recognized as blue spots in ultra-violet light after being sprayed with a mixture of potassium ferricyanide and sodium hydroxide in alcoholic solution.

The different shape of the thiamine spot *T* in chromatograms *E* and *K* is due to the high concentration of added thiamine in the yeast extract after the phosphorylation process has been stopped.

The chromatograms give evidence of a marked ability of bakers' yeast to synthesize not only thiamine diphosphate but also thiamine triphosphate from thiamine.

A full description of this investigation will be published later in connexion with a comprehensive work on the synthesis and occurrence of thiamine phosphates.

K.-H. Kiessling

Institute of Zoophysiology,
University of Uppsala. Sept. 14.

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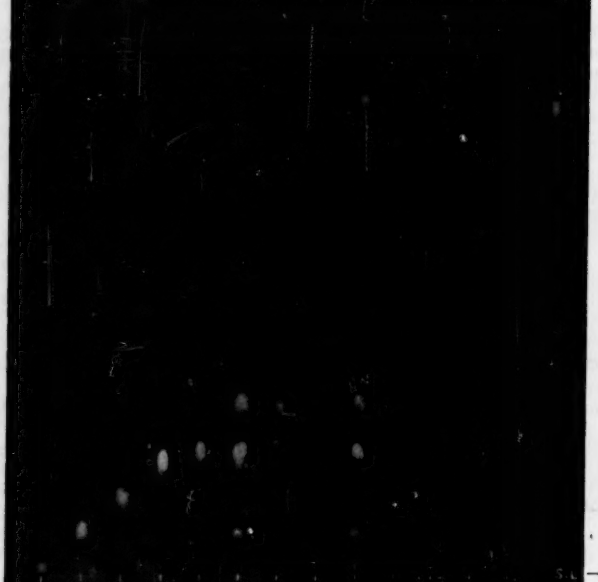
Isolation of *l*-Quinic Acid from the Peach Fruit

Malic and citric acids had been the only acids found in quantity in peaches[1], but Peynaud[2] showed that they accounted for only 40–80 per cent of the total acidity. Hulme and Swain[3], using paper chromatography, found that the pulp of the peach fruit contained an acid which had the same R_F value as an unknown acid in apples, later shown to be *l*-quinic acid[4]. Using displacement chromatography on an anion-exchange resin, pure *l*-quinic acid has now been isolated from ripe peaches, in which it is sometimes the major acid.

A set of columns of decreasing diameter[5] was packed with the strong-base anion-exchanger, 'Amberlite *IRA*-400'. Using three columns, mixtures of known acids were resolved by displacement with 0·1 *N* hydrochloric acid. The acids emerged in the following sequence: acetic, quinic, galacturonic, succinic, α-hydroxyglutaric, malic, tartaric, citric, malonic, α-ketoglutaric, oxalic and hydrochloric. The separation was sharp, except for the contamination of oxalic acid with hydrochloric acid. Similar results were obtained with columns of 4 per cent cross-linked 'Dowex 1', using either the hydroxide or the acetate form, even with three columns containing 3, 1 and 0·3 gm. of resin respectively.

Starting with an 80 per cent alcoholic extract, an aqueous solution was prepared which contained the water-soluble constituents from approximately 2 kgm. of ripe peaches. The bases and amino-acids were removed with a cation-exchanger and the acids were collected on a column of the weak-base anion-exchanger 'Amberlite *IR*-4*B*'. This column was washed to remove sugars, and the acids were eluted with 2 *N* ammonia. The solution of peach acids was freed from ammonia and carbon dioxide, and run on to a set of five columns of 'Amberlite *IRA*-400'. The acids were displaced with 0·1 *N* hydrochloric acid, and the effluent was collected as 300 fractions of equal volume. Since the acids emerged in 0·1 molar solution, the molar proportion of each acid in the mixture could be estimated from the number of fractions collected. This calculation was confirmed by titration. The acids were identified by means of paper chromatography in two solvents and by the sequence of emergence from the columns, which was as follows: *l*-quinic, galacturonic, a mixture of minor acids including succinic, *l*-malic, citric and phosphoric, followed by the hydrochloric acid front. Successive acids overlapped by not more than three fractions. *l*-Quinic, *l*-malic and citric acids crystallized readily when the appropriate fractions were concentrated. One recrystallization from water gave pure *l*-quinic acid as colourless prisms of melting point 168° (literature[6] 162°) with $[\alpha]_D^{20} = -44°$ (literature[6] $[\alpha]_D^{20} = -44°$). The galacturonic acid was converted to mucic acid, and the phosphoric acid fractions gave the ammonium molybdate test. Eventually the acids from approximately 200 gm. of peaches were run on to three small columns and about thirty fractions were collected. The minor acids, including galacturonic acid, occupied two fractions and the other acids overlapped in one or two fractions.



Descending paper-chromatogram on No. 1 Whatman paper, run 18 hr. in methyl ethyl ketone – cineole – formic acid – water (50 : 50 : 20 : 16 v/v), sprayed with glucose and ammoniacal silver nitrate, fixed with thiosulphate. Acids: (1) galacturonic, (2) quinic, (3) tartaric, (4) phosphoric, (5) citric, (6) peach acids, (7) malic, (8) glycollic, (9) mixture of (1), (2), (5), (7), (8), (11) and (14), (10) α-ketoglutaric, (11) malonic, (12) succinic, (13) itaconic, (14) fumaric. *S.F.*, Solvent front; *S.L.*, starting line

Table 1. PEACH ACIDS (MOLES PER CENT)

	Blackburn Elberta from Wedderburn, N.S.W.			J. H. Hale from Bathurst, N.S.W., 1950	Golden Queen from Leeton, N.S.W., 1950
	1950	1951	1952		
Quinic	28	40	38	18	16
Malic	40	30	20	47	64
Citric	25	22	36	28	12
Phosphoric	5	4	½	5	5
Others	2	4*	5½*	2	3

* Includes significant amounts of galacturonic acid.

The acids from three varieties of peaches grown in different locations, and from Blackburn Elberta peaches taken from the same orchard in three successive years, were separated as described. There was a considerable proportion of quinic acid in all the samples, and it was the major acid in one sample of Blackburn Elberta (see Table 1). All the peaches used were eating-ripe; some samples of less mature peaches will be tested next summer.

The two solvent mixtures mainly used for paper chromatography were alcohol – ammonia – water[7] and methyl ethyl ketone – cineole – formic acid – water (50 : 50 : 20 : 16 v/v). Cineole was used to hasten the removal of formic acid[8], and methyl ethyl ketone, in place of an alcohol, to avoid the difficulties caused by esterification. The separation of the acids (see photograph) was as good as that obtained with other solvent mixtures. A similar mixture containing mesityl oxide[9] gave very low R_F values. A permanent record of the acid spots was obtained by spraying with glucose and silver nitrate[10], and then fixing the paper with 1 per cent sodium thiosulphate.

E. F. L. J. ANET
T. M. REYNOLDS

Division of Food Preservation and Transport,
Commonwealth Scientific and
Industrial Research Organization,
Homebush, N.S.W. Aug. 20.

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Seasonal Variation in the Regeneration of Root-Cuttings

THE recent publication of Hudson[1] recording an annual fluctuation of regenerating capacity in raspberry root-cuttings is paralleled by a number of observations on root-cuttings of horse-radish (*Armoracia rusticana*) made incidentally in this Department in the course of other work. These observations indicate that under constant conditions horse-radish cuttings show a seasonal variation in regenerating capacity, expressed as the mean number of primordia formed per root-scar in 10–14 days (Fig. 1). The results shown are at present incomplete, but it is hoped to extend them in the future. The point of particular interest, however, is that the regenerating capacity is low during the months of flowering (in *Armoracia*, during May and June); and an inspection

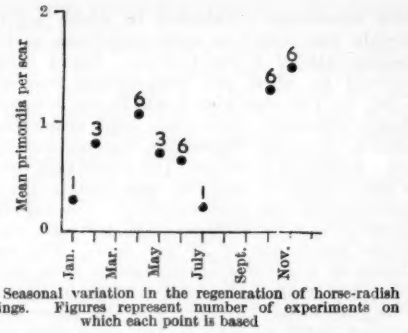

Fig. 1. Seasonal variation in the regeneration of horse-radish root-cuttings. Figures represent number of experiments on which each point is based

of Hudson's graph shows that the same relationship holds for the raspberry (flowering June to August).

Examination of a propagation table given by Graham[2] shows that of twelve species, all regenerating from the roots in the same manner as horse-radish and raspberry, five regenerate most efficiently before flowering, three after flowering, two regenerate most efficiently in the flowering month and also in another month, and two regenerate efficiently only during the flowering months. Similarly, of twelve species which regenerate from stem cuttings, five regenerate most efficiently before flowering, five most efficiently after flowering, and only two actually during flowering.

It is apparent that the antagonism between regenerating capacity and flowering is quite widespread and, apart from its possible biochemical implications, may have an important bearing on competition and survival in such plants.

J. DORE

Department of Botany,
University of Southampton. Nov. 2.

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Sperm Storage and Cross-Fertilization of Spring and Autumn Spawning Herring

THIS preliminary communication gives the results of some experiments conducted at the Marine Laboratory, Aberdeen, in 1953, as part of a more extensive herring-rearing programme. They show that it is possible to cross-fertilize the two spawning 'types' of herring (*Clupea harengus*) found in the north-east Atlantic, one of which spawns in the spring, the other in the autumn.

To achieve this, a technique of long-term gamete storage is required. Polge, Smith and Parkes[1] first reported that fowl spermatozoa stored in dilute glycerol at − 79° C. remained alive for as long as nine months; Polge and Rowson[2] found that bull spermatozoa remained fertile after storage for nine months under these conditions. Similar methods were therefore applied to the storage of herring gametes.

Ripe spermatozoa and eggs were obtained in March 1953 from spring-spawning herring caught in the Firth of Clyde. Two samples of each of the ovary and testes were removed by dissection and placed in sealed tubes containing a solution of 12·5 per cent glycerol in diluted sea water (one part distilled water to four parts sea water). After an interval of thirty minutes at a temperature of about 8° C., one sample of each was frozen rapidly by placing it in solid carbon dioxide (− 79° C.). The other two samples were cooled slowly by immersing

their containers in alcohol to which solid carbon dioxide was added in such quantities as to give a cooling rate of 1 deg. C./min. Rapid cooling was resorted to when the temperature reached about − 30° C. The eggs were found to die, but the spermatozoa remained alive when kept under these conditions. In early September, ripe autumn-spawning herring became available. The stored milt was thawed in water at 40° C. and the eggs from a ripe autumn-spawning herring were fertilized. The rapidly-frozen sperm gave a fertilization of 85 per cent, the slowly-frozen sperm one of 80 per cent. The eggs were placed in a constant-temperature tank at 11·5° C. and 5 per cent of the total number of eggs hatched. This percentage hatching was the same as that of another batch of eggs in the same tank for which both parents were autumn spawners.

This storage technique opens up possibilities for testing the interfertility of closely related fish species and other animals with different spawning times or places. Reproductive isolation is one of the criteria used in defining a species, and experiments such as that described above might be of value to the systematist. It is proposed to extend these experiments to other 'types' of herring and to other species of Clupeoids.

My thanks are due to Dr. J. E. Lovelock, of the National Institute for Medical Research, Mill Hill, London, for his advice on sperm storage, to Mr. B. B. Parrish, of this Laboratory, for generous advice and help on herring matters, and to Mr. D. Mills, for assistance in this work.

J. H. S. Blaxter

Marine Laboratory,
Aberdeen. Nov. 9.

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Naras Seed Protein

The naras (*Acanthosicyos horrida*, Hook) is a cucurbitaceous plant, which occurs particularly near Walvis Bay in South-West Africa. The fruit is a small melon consisting of an outer rind and six segments which contain numerous seeds. The fruits and the seeds derived from them were extensively used as foods by the desert dwellers of the area in earlier days, and are still used to some extent in this way. More recently, the seeds have been collected and exported to South Africa, where they have found use in the confectionery industry. Versfeld and Britten[1] found that the seed kernels consist mainly of protein (35 per cent) and fat (53 per cent).

The proteins of oil-free naras seed meal were extracted with 10 per cent sodium chloride and then four volumes of water were added to each volume of the extract, causing precipitation of the extracted protein. The protein obtained resembles edestin[2] in being soluble only in buffers of relatively high salt concentration. Measurements on a Brice–Phoenix light-scattering photometer[3], using the ultrafiltration method of Goring and Johnson[4] for the clarification of the solutions, gave a molecular weight of 343,000 at ionic strength (I) 1·0 and pH 7·8 for this preparation.

In a second preparation the proteins extracted with 10 per cent sodium chloride were precipitated by saturating the extract to 45 per cent with ammonium sulphate. This preparation gave a light-scattering molecular weight of 341,000 at $I = 1·0$ and pH = 7·9. Thus, the two preparations probably

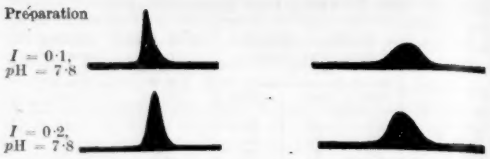

Fig. 1. Electrophoresis diagrams of naras seed protein–sodium dodecyl sulphate complexes

represent the same protein fraction, and have a molecular weight comparable with values reported for other seed globulins[5].

Whereas naras seed protein is only soluble in buffers of high salt content ($I = 1·0$), it is rendered soluble in buffers of low ionic strength ($I = 0·1$) by the addition of 1 per cent sodium dodecyl sulphate. This fact alone seems to indicate that a detergent-protein complex is formed. The electrophoretic diagrams (shown in Fig. 1) obtained for complexes prepared at $I = 0·1$ and 0·2 at pH = 7·8 indicate that these are electrophoretically homogeneous. The light-scattering molecular weights of these complexes are shown in the table.

Preparation	$\frac{dn}{dc}$	Molecular weight	Uptake of sod. dodecyl sulph. (gm./gm. protein)
Original protein $I = 1·0$ pH = 7·8	0·188	342,000	—
Complex at $I = 0·1$ pH = 7·8	0·164	98,000	0·47
Complex at $I = 0·2$ pH = 7·8	0·164	163,000	0·47

The molecular weights of the complexes are very much lower than that for the original protein, due to a breakdown of the protein in complex formation. Although the detergent uptake for the two complexes is the same, nevertheless there is a considerable difference in the respective molecular weights. Calculations from the known composition of the complexes have shown that complexes with sodium dodecyl sulphate have been formed in which the weight of protein per molecule of complex is about 56,000 and 110,000 for preparations at $I = 0·1$ and $I = 0·2$ respectively. This suggests breakdown of the original protein molecule into sixths at $I = 0·1$ and thirds at $I = 0·2$.

When arachin was treated with sodium dodecyl sulphate under similar conditions[6], an extensive breakdown of the protein occurred, but the sedimentation constants, and hence molecular weights, at $I = 0·1$ and 0·2 were of the same order.

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F. J. Joubert
D. R. Cooper

National Chemical Research Laboratory,
South African Council for
Scientific and Industrial Research,
Pretoria, South Africa. Aug. 26.

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Inhibition of *Fusarium culmorum* by *Streptomyces albidoflavus*

THOUGH soil actinomycetes can sometimes elaborate antibiotics when grown in unamended sterile soil[1], it has usually been found necessary to enrich such soils with energy sources in order to demonstrate production of antibiotic[2]. In unsterile soil cultures, production of actinomycete antibiotics in clearly detectable amounts has only rarely been reported[3]. The following investigation was made to determine the ability of *Streptomyces albidoflavus* to inhibit the growth of the fungus *Fusarium culmorum* under a variety of nutritive conditions and particularly with small amounts of readily available carbohydrate—conditions likely to be unfavourable for luxuriant growth of either organism.

When both organisms were seeded at a distance from each other on plates of mineral salt solution agar containing 1 per cent glucose, growth of the fungus towards the actinomycete was checked. With only 0·01 per cent glucose, the check was never complete and fungal hyphæ grew slowly but steadily towards the actinomycete. The effects of other sources of energy, more likely to be present in soil, were then tested. The actinomycete and the fungus were placed at a distance on plain agar buffered to *p*H 7, and dry, finely milled organic matter was spread over each organism but not over the space between the organisms, so that growth of the fungus towards the actinomycete could be observed. On control plates without added organic material, growth of the fungus was slightly inhibited. Strong inhibition was obtained with dried grass. However, with wheat straw, roots, farmyard manure, leaf mould, peat and 'lignin', antagonism was even less than on the control plates with no added material. All these organic materials and clear extracts of them destroyed the antibiotic activity of actinomycete culture filtrates to which they were added. Presumably, on the agar plates, dried grass enabled the actinomycete to produce an amount of antibiotic in excess of that destroyed by it. Bentonite was very effective in removing antibiotic activity of actinomycete culture filtrates, presumably by adsorption. This effect was also exerted, though to a less extent, by other clays and by whole soils. Bentonite, when added to an agar medium, also strongly reduced antagonism between the actinomycete and the fungus.

When both organisms were grown together in sand culture, the addition of bentonite reduced but did not completely prevent inhibition of *F. culmorum* by the actinomycete. Thus, the actinomycete could inhibit the fungus by means other than antibiotic action.

A direct lysis of the contents of the fungal hyphæ by actinomycete mycelium in contact with it was observed in sand culture. This direct attack was prevented or greatly reduced by the presence of bentonite which, presumably, adsorbed the lytic agent. There was evidence that the actinomycete did not influence growth of the fungus in sterile soil either by antibiotic action or by direct attack, but that there was some competition between the organisms for nutrients or space.

In sand cultures there was a direct relation between the amount of glucose supplied and the antagonistic effect of the actinomycete. This relation was also found when bentonite was present, so that a high level of glucose presumably increased competition for limiting nutrients as well as influencing the production of antibiotic secretions. Lysis of the fungus was also most evident at high concentrations of glucose. Survival of both organisms together was favoured by low concentration of glucose. It would appear, therefore, that the conditions which favour the luxuriant development of an organism growing in pure culture may often be those that will tend to prevent its growth in association with others.

F. A. SKINNER

Soil Microbiology Department,
Rothamsted Experimental Station,
Harpenden, Herts. July 29.

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An Unknown Acid from Brain Extracts chromatographed on Silica Gel

SINCE partition chromatography on silica gel allows the simultaneous quantitative determination of the individual acids of the polycarboxylic acid cycle[1,2], it became of interest to apply this technique to the measurement of the organic acids in brain tissues. Fig. 1 shows the chromatographic pattern of the

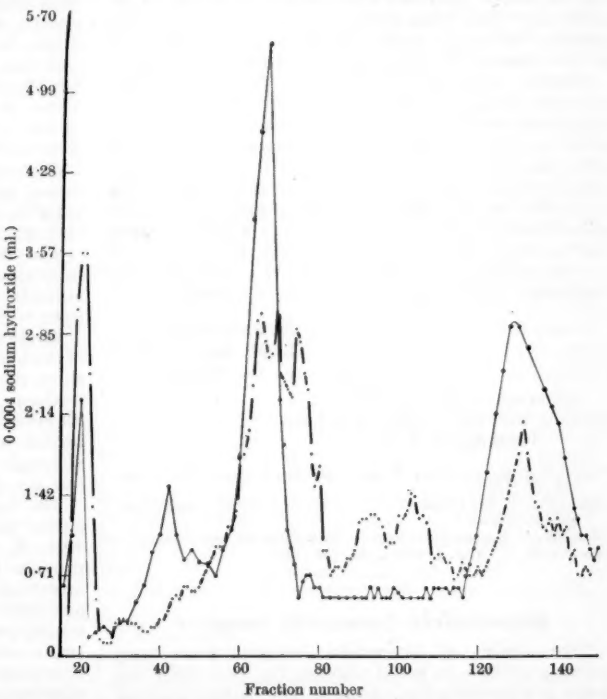

Fig. 1. Typical curves resulting when 1 gm. of brain tissue taken from man and turtle is chromatographed as under refs. 1 and 2. Each fraction represents 1·5 ml. of effluent. The values for human brain tissue might be exaggerated because of anæsthesia used during the operation. Full line, human; broken line, turtle

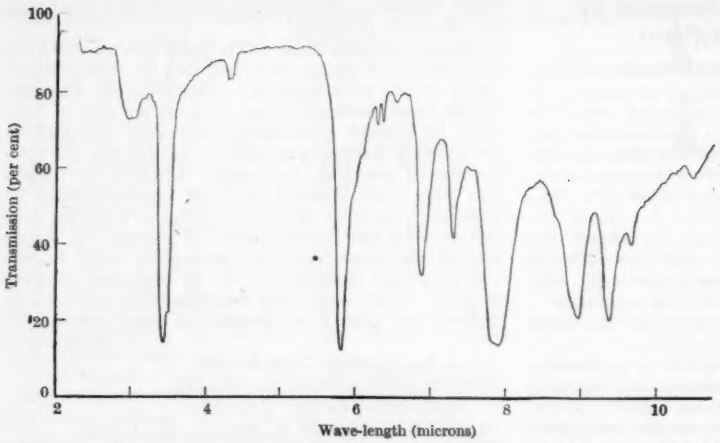

Fig. 2. Infra-red spectrum of an isolated unidentified compound from the brain (fractions 130–150). Film made on sodium chloride crystal

tertiary amyl alcohol – chloroform (50 per cent v/v) extract of human brain. (Identical patterns were found for these extracts from guinea pigs, mice, rabbits, turtles and chickens.) The first peak of the chromatogram (fractions 15–25), composed of a mixture of free and esterified fatty acids[3], was followed by a smaller peak (fractions 40–50) for fumaric acid. Then, there is a large peak (fractions 60–80) representing mainly lactic acid but also small amounts of succinic acid. The lactic acid was identified by measuring the colour produced when concentrated sulphuric acid and P-hydroxydiphenyl were added[4]. The presence of alpha ketoglutarate is often indicated by the presence of a shoulder to the right of this curve.

Finally, there is a pronounced peak due to an unidentified acid (fractions 130–150). When chromatographed with a mixture of oxalic acid and L-malic acid, the unknown acid appears between them on the chromatogram (pattern not shown here). The compound contains 54·3 per cent carbon and 10·4 per cent hydrogen, and the absorption in the infra-red (Fig. 2) shows the CH-stretching vibration (3·4 microns) and the carbonyl stretching (5·8 microns) vibration.

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F. Friedberg
L. M. Marshall
L. H. Newman

Department of Biochemistry,
Howard University Medical School,
Washington 1, D.C.

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Bacteria-free *Entamoeba invadens*

Two strains of *Entamoeba invadens* have been growing *in vitro*, on serial transfer, for more than two years in a bacteria-free medium. The culture medium used initially[1] has been simplified and now consists of 10 ml. of 0·75 per cent saline solution to which is added a slice of hamster liver, and the culture is sealed with a layer of petroleum jelly. Liver slices from rats, rabbits, guinea pigs, chickens, pigs and hamsters, have been tested and found to support good growth of the bacteria-free *E. invadens*. The liver cubes used measure 2–4 mm. a side. Limited experiments demonstrate that chicken-breast muscle and rat-heart muscle will also support *in vitro* growth of amœbæ in the absence of bacteria.

The cultures of bacteria-free amœbæ do not normally encyst when grown in this manner, but will remain viable at room temperature for periods up to ten weeks. Our practice is to transfer cultures every three or four weeks. Growth of the amœbæ can be followed by focusing the 16-mm. objective of the microscope on the inner surface of the wall of the culture-tube where the amœbæ adhere.

Liver tissue has been crushed with sterile precautions in a Shiver's tissue grinder and used in place of the liver slice without affecting its growth-promoting qualities. Further, it has been found that liver tissue made into a suspension in saline will support growth of the bacteria-free amœbæ, as will the supernatant of this liver suspension when centrifuged. In our studies, we have added approximately 4 gm. liver tissue to 50 ml. of 0·75 per cent saline, homogenized the liver in a Waring blendor and then centrifuged the suspension at 3,000 r.p.m. for 90 min.; 1 ml. of the supernatant is added to 10 ml. of 0·75 per cent saline solution and the surface of the liquid sealed with a layer of petroleum jelly. The medium thus prepared will support growth of bacteria-free *E. invadens*. The growth-promoting factor present in the supernatant of the liver suspension is almost entirely removed when passed through a Seitz or fritted glass filter.

The results of culture experiments using a dialysing membrane to separate the liver from the amœbæ indicate that the growth-promoting substance in the liver is not dialysable.

Studies to test the effect of heat on the ability of the liver suspension to support growth of *E. invadens* show that 100° C. for 5 min. inactivates the culture medium; 50° C. for 30 min. does not appear to impair its growth-promoting qualities, and liver suspensions heated at 56° C. for 30 min. will support growth although growth of the amœbæ is not so abundant nor do the amœbæ live as long.

The results of studies in progress indicate that garter snakes (*Thamnophis*) experimentally infected with *E. invadens* from bacteria-free cultures may provide useful information on the pathogenesis of amœbiasis. It has already been observed that associated bacteria influence the course and intensity of the amœbic infections and that, of the two strains of *E. invadens* studied in our laboratory, one is more virulent than the other. Finally, these infections show a definite response to subcutaneous injections of emetine, and may well provide a convenient method for the evaluation of amœbicidal drugs.

This work was carried out in the Institute of Parasitology, McGill University, Macdonald College, P.Q., Canada, with financial assistance from the National Research Council of Canada.

MAX J. MILLER
Liberian Institute of the
American Foundation for Tropical Medicine,
Harbel, Liberia.

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Absence of 'Incomplete' Virus Production in certain Influenza Strains

CONCENTRATED allantoic inocula of *PR*8 (influenza *A*) virus give rise to particles having the antigenic make-up, hæmagglutinating power and enzymic activity of the seed, but lacking infectivity. Since it bears some resemblance to interference by an unrelated virus, the phenomenon was named 'auto-interference'[1]. The use of this term was rather unfortunate: partly because Ziegler *et al.*[2] had previously proposed it to describe the behaviour of old virus preparations containing a large proportion of non-viable particles, as first observed by Henle and Henle[3]; and partly as it led to the belief that incomplete virus was produced by cells infected by more than one virus particle. Indeed, extensive theoretical predictions have been based on this assumption[4]. Experiments, however, soon revealed that, whatever its mechanism, multiplicity of infection cannot be implicated to account for the facts, as incomplete virus was produced when only 1 per cent of the cells had been infected[5]. This piece of negative evidence brought forward by Cairns and Edney is in itself sufficient to invalidate the hypothesis; here positive proof is furnished that certain strains of influenza virus do *not* produce incomplete particles even under conditions of multiple infection.

Fresh preparations of influenza viruses were inoculated into groups of six 11-day-old eggs, 0·6 ml. volumes of undiluted seed ($10^{9\cdot16}ID_{50}$) or a 10^{-4} dilution being given allantoically. Samples of allantoic fluid were removed at the height of infectivity (after 24 and 48 hr. respectively), and each fluid was titrated for hæmagglutinin against 0·25 ml. 1 per cent fowl red cells, and for infectivity in log 0·5-fold steps employing five eggs per dilution. The results obtained with the two classical strains, *PR*8 (*A*) and *LEE* (*B*), are sufficient to establish our thesis; the detailed findings with these and several other strains will be published elsewhere.

Inoculum		Yield*			Evaluation†	
Strain	Dilution	ID_{50}/ml.	*HA*/ml.	*ID*/*HA*	*F*	*P*
*PR*8	10^{0}	7·44	3·34	4·10±0·138	88·56	<0·001
	10^{-4}	9·97	3·47	6·50±0·214		
LEE	10^{0}	9·56	3·20	6·36±0·136	1·61	~0·3
	10^{-4}	9·46	3·22	6·24±0·135		

* Geometric mean and standard error of six parallel experiments (expressed in $\log_{10}$ units).
† Results of an analysis of variance; *F* = variance ratio, *P* = probability of the difference being due to chance.

It is evident that whereas the *PR*8 strain shows the typical behaviour described by von Magnus[1], no non-infective virus is produced by the *LEE* strain, although multiple infection has been ensured by the fact that the initial inoculum contained approximately eight times as many ID_{50} as there are infectible cells. Thus the simultaneous infection of a cell by several homologous influenza virus particles does not necessarily result in depression of infective virus production. Consequently, the term 'auto-interference' prejudices our understanding of the underlying mechanism, and should not be used in connexion with incomplete virus production; it is best reserved for the phenomenon to which it has been appropriately applied by Ziegler and his associates[2].

S. FAZEKAS DE ST. GROTH
DORIS M. GRAHAM
Department of Microbiology,
John Curtin School of Medical Research,
Australian National University,
Canberra, Australia.
Aug. 13, 1952.

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Possible *P*–*Q* Type Variation in Infectious Laryngotracheitis Virus

FROM an outbreak of acute infectious laryngotracheitis in South Australia[1] a strain of virus was isolated which proved to be highly resistant to neutralization by antisera in the pock neutralization test. On intratracheal inoculation into susceptible birds, it gave rise to typical acute infectious laryngotracheitis in about four days, produced a typical vaccination reaction when given by the cloacal route and gave rise to antibodies fully active against a type infectious laryngotracheitis virus. On primary isolation it showed some degree of resistance to neutralization by its homologous and other infectious laryngotracheitis antisera, but after storage for eight months in the 'dry ice' refrigerator it was almost completely resistant to neutralization by all available antisera (see table). Prior to this outbreak, infectious laryngotracheitis was not known to be present in South Australia despite a careful watch being kept, and no spread of the typical explosive epidemic form of the disease in other flocks has followed this outbreak. A survey of hens throughout South Australia showed that, at the time of isolation of this strain, about 50 per cent of the flocks had birds with demonstrable infectious laryngotracheitis antibodies in their sera.

A similar phenomenon was reported by Burnet[2] in 1936 in strains of infectious laryngotracheitis isolated in Victoria and New South Wales. Burnet stated that "no qualitative antigenic differences can be detected amongst these strains but the epizootic (N.S.W. and BAI) strains are more readily neutralised by immune serum than the enzootic Victorian strains".

POCK NEUTRALIZATION TESTS

Exp. No.	Virus	Antisera: Local strain (*A*)	Antisera: Reference strain (*S*)
1	*A*	1·0	1·5
Fresh virus	*S*	1·8	1·9
2	*A*	0·3	0·0
Stored virus	*S*	1·7	2·1

The figures are the logarithms of the ratio of foci developing on the experimental to those on the control membranes.

He also recorded a reduced pathogenicity in the Victorian virus. Van der Veen and Mulder[3] described a variation in influenza *A* prime virus in which certain strains (*P*) had a high avidity for antibody, whereas others (*Q*) had a low avidity. Isaacs and Andrewes[4] and later Isaacs[5] confirmed this work and induced *P–Q* and *Q–P* variation in the laboratory. These latter workers advanced the theory that the *Q* variant, being able to survive in the presence of antibody, was a means of inter-epidemic survival.

It appears that the infectious laryngotracheitis and influenza variants have several points in common. Designating the South Australian and Victorian strains of infectious laryngotracheitis as *Q* and the classical strains as *P*, we find that, first, the infectious laryngotracheitis and influenza *Q* strains have a low avidity for antibody whereas the *P* strains of both have a high avidity. Secondly, the *Q* strains of both have been isolated from endemic areas or periods, or at the transition at the opening or closing of an epidemic, whereas the *P* strains of both have as a rule been isolated during epidemics. Thirdly, Burnet demonstrated a lowered pathogenicity in Victorian (*Q*) strains. This has not been demonstrated in the South Australian strains, due possibly to the virus being in an intermediate phase when first isolated. The widespread occurrence of antibodies and the absence of clinically recognizable infectious laryngotracheitis in South Australia and the inter-epidemic history of influenza, however, suggest a reduced pathogenicity. Lastly, the phase variation in influenza has been produced under laboratory control. The evidence for infectious laryngotracheitis in this respect is not at present convincing, but our South Australian strain when first isolated behaved in a manner not inconsistent with Isaacs's mixed *P–Q* (*A*/Persian Gulf/2/52) and, after prolonged storage, behaved as a *Q* strain. This may have been an accidentally induced selection to a *Q*-type variant in a previously mixed strain. It is of interest that our strain of infectious laryngotracheitis was isolated from a flock in which no previous experience of the disease was evident from sera taken within the first week of the epidemic, yet in an area in which some form of it appears to be endemic.

The lytic-symbiotic mutation cycle in bacteriophage described by Boyd[6] appears to serve the same epidemiological function as the influenza and infectious laryngotracheitis variations. In the phage we have, on one hand, a phase which is described as non-pathogenic, inter-epidemic and associated with the maintenance of the species; and on the other, a phase which is 'epidemic', rapidly destructive of its host and provides a wide dissemination of the species. It is not to be expected that the antigenic differences of the animal viruses would be found in the phage variation, as in this case it is not a factor associated with the host–parasite relationship. Boyd, in describing this variation in phage, speculated that were such a cycle present in other viruses it would provide a more convincing explanation of the way in which a virus maintains itself in the inter-epidemic period than a chain of subclinical infections. It is not necessary to postulate a complete symbiotic existence in the inter-epidemic period to be consistent with Boyd's views. Any mutant which is able to survive in the immune host without causing undue symptoms would meet the requirements.

M. F. Pulsford
Institute of Medical and Veterinary Science,
Adelaide, South Australia.
Aug. 27.

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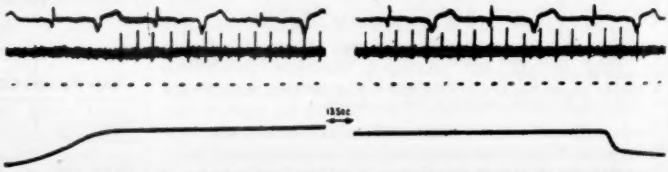
Impulses in Vagal Afferent Fibres from Stretch Receptors in the Stomach and their Role in the Peripheral Mechanism of Hunger

It has been shown that there are in the cervical vagus of the cat certain afferent fibres which yield a discharge of impulses a few seconds after an intravenous injection of phenyldiguanide[1] or 5-hydroxytryptamine[2]. The normal functions of these afferents have now been investigated. Most of these afferents end in stretch receptors in the wall of the stomach; apparently this is the first description of such receptors.

As shown in the accompanying figure, these fibres yield a discharge of impulses when the stomach is distended with a balloon. Although the threshold of distension necessary to stimulate the receptors varied from 10 to 150 ml., all the gastric receptors so far encountered showed a great similarity in their pattern of response. The discharge in some fibres showed no tendency to become adapted during a maintained distension; in others a slow rate of adaptation occurred; in no case was a rapidly adapting discharge observed. The relation between the degree of distension and the frequency of impulses has been found to be linear. These gastric receptors, for which histological evidence exists[3], would therefore appear to be similar to other well-known stretch receptors, in this particular case their function being to signal the degree of distension of the stomach. The afferents concerned run in the vagi, and these must inevitably play an important part in the various reflexes connected with the stomach. Apart from this, since they must obviously be more active after a meal, they might be responsible for the feeling of satiation. A reduction or absence of these impulses would in that case tend to produce hunger, and on this hypothesis the hunger pangs could be explained as being due to a further reduction in the number of impulses during each contraction. In this connexion the observations and conclusions of previous investigators are relevant[4].



Response of a gastric stretch afferent fibre to a maintained distension of the stomach. From above downwards: e.c.g.; impulses in a gastric stretch fibre; time in 0·1 sec.; intragastric pressure. The frequency of discharge is unaltered throughout the period of distension

A number of drugs when injected into the thoracic aorta produce a discharge of impulses similar to that produced by 100 μgm. phenyldiguanide. Among them are 5-hydroxytryptamine (100 μgm.), lobeline (1 mgm.), nicotine (1 mgm.), adrenaline (100 μgm.), and glucose (0·5 gm.). The depressing effect of adrenaline on hunger could, therefore, be explained by its stimulating action on gastric stretch receptors. Further, a new concept is provided for the association of blood-sugar levels and hunger. With the present hypothesis it would thus seem possible to reconcile the diverse views and observations on the peripheral mechanism of hunger.

My thanks are due to Dr. J. C. Mott for the supply of phenyldiguanide, to Messrs. Abbot Laboratories, Chicago, for the supply of 5-hydroxytryptamine, and to Mr. Y. C. Wal for much technical assistance.

A. S. Paintal

Physiology Branch,
Technical Development Establishment Laboratories,
Kanpur, India.
Aug. 1.

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Effect of Two Systems of Management on Milk Yield and Body Temperature of Dairy Cattle

In the winter season in Egypt, cattle are either kept indoors and provided with barseem (*Trifolium alexandrinum*), or taken to the fields and fed with the same ration for a period of about ten hours during the day. The experiment described here was carried out at the University Experimental Farm, Alexandria, in order to study the effect of the two systems of management on milk-yield and body-temperature of dairy animals.

Two groups of native cows, each of three individuals, nearly in the same stage of lactation, were subjected to the indoor and the outdoor conditions for ten days alternately for a total period of 80 days. Therefore each group of cows spent 40 days in each of the two systems. Milk yield was recorded three times daily, and the rectal temperature was read at each milking. The average results obtained are given in Table 1.

There are no significant differences between the milk yield and body-temperature of the cows in the two systems. These results might only be expected in certain conditions. However, the average temperature in the stable during the period of study ranged between 13·4° and 21·5° C., whereas the corresponding atmospheric temperature was 12·5° and 19·7° C. respectively.

Table 1

	Outdoor system	Indoor system
Milk yield (lb.)		
at 7.00 a.m.	6·25 ± 0·183	6·20 ± 0·208
,, 1.30 p.m.	3·85 ± 0·137	3·85 ± 0·116
,, 9.00 p.m.	3·85 ± 0·139	3·88 ± 0·126
Average	4·65 ± 0·153	4·64 ± 0·150
Body temperature (° C.)		
at 7.00 a.m.	37·9 ± 0·052	37·8 ± 0·049
,, 1.30 p.m.	38·2 ± 0·044	38·2 ± 0·044
,, 9.00 p.m.	38·1 ± 0·047	38·0 ± 0·047
Average	38·1 ± 0·047	38·0 ± 0·046

K. A. Alim

Department of Animal Production,
Faculty of Agriculture,
Alexandria University.
Sept. 2.

Occurrence of *Pterophyllum* in the Parsora Beds, South Rewa, India

During February–March 1953, a collection of fossil leaf impressions was made by me from several localities of the South Rewa Gondwana basin, including the well-known locality of Parsora, the floral assemblage of which raised a long-held controversy regarding the age of these beds and their position in the Gondwana system of India. The flora will be described in detail elsewhere. In this communication, I wish to record the finding of two specimens of a hitherto unreported frond recalling *Pterophyllum*. The frond (Fig. 1) is incomplete, pinnate, with a stout and straight rachis measuring 17 cm. in length; 6 cm. in breadth; pinnæ linear, closely set, more or less equal in breadth with one exception, attached to the rachis at right angles and by the whole of their slightly decurrent bases; maximum length exposed of the pinnæ 10 cm. and average breadth 3 cm.; veins many, averaging fifty, distinct, 0·5–0·8 mm. apart, usually bifurcating close to their emergence, where they take a narrow upward curve and then run parallel to the edge of the pinna, rarely showing bifurcation again.

In general appearance and form, the Parsora specimens bear some resemblance to *Nilssonia princeps* (Old. and Morr.) Seward, and to certain large fronds of *N. compta* (Phillips) Bronn[1]. Since not many specimens are available for study at present, it is difficult to say whether on the other side of the frond, which is not exposed to view, the pinnæ are

Fig. 1. *Pterophyllum* sp. from the Parsora beds (× about ½)

continuous over the rachis as is characteristic of *Nilssonia*. However, the pinnæ in my specimens seem to be laterally attached as in *Pterophyllum*. In addition to this, the bifurcation of the veins close to their emergence and the presence of almost equal pinnæ are strongly suggestive of *Pterophyllum*. I am, therefore, inclined to believe that these fronds belong to *Pterophyllum*.

The age of the Parsora beds is still in dispute and, although a definite opinion cannot be expressed at present, the vertical range of some of the important plant fossils which reflect upon the age of the Parsora flora can be briefly stated here. *Danaeopsis hughesi*[2], which occurs in abundance at Parsora, ranges from Keuper to Rhætic. Another Parsora species, namely, *Thinnfeldia odontopteroides*[3], is characteristic of Rhætic or Upper Triassic. The genus *Pterophyllum*[4], which has now been found in the Parsora beds, is known to range from the Upper Carboniferous to the Lower Cretaceous, but it is especially characteristic of the Keuper and Rhætic floras.

My thanks are due to Dr. K. R. Surange for his helpful suggestions.

K. M. Lele

Birbal Sahni Institute of Palæobotany,
53 University Road,
Lucknow.
Sept. 1.

[1] Seward, A. C., "Jurassic Flora", 1, 227 (1900).
[2] Seward, A. C., "Fossil Plants", 2, 409 (1910).
[3] Seward, A. C., "Fossil Plants, 2, 538 (1910).
[4] Seward, A. C., "Fossil Plants", 3, 551 (1917).

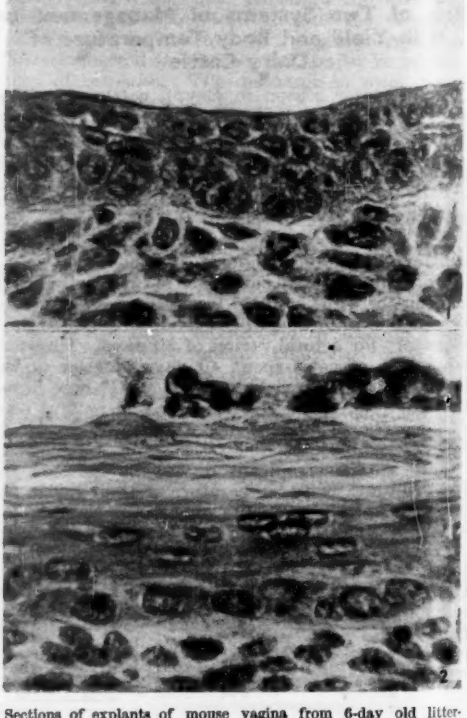
Vaginal Cornification of the Mouse produced by Œstrogens *in vitro*

Several workers have successfully grown parts of the genital tract in tissue culture, but only a few studies have been concerned with the action of œstrogens under these conditions. Gaillard[1] was able to stimulate the uterus and seminal vesicles with œstrone, whereas Emmens and Ludford[2] failed to induce keratinization in explants of rat vagina with œstradiol-3 : 17β. Recently, we have successfully cultured the vagina of the mouse and produced keratinization by the addition of œstrogens to the culture medium.

Three six-day old litter-mates were taken from a mixed albino stock. The genital tract was dissected out and the vagina cut into six rings, each being spread on the surface of the medium in a hanging-drop preparation. This medium consisted of two drops of plasma from a cock seven months old, and one drop of 1 : 1 extract with Tyrode solution of a chicken embryo of eleven days incubation. Two explants from each mouse were cultivated on the basic medium alone (control group), two had in addition 0·01 ml. of Tyrode solution containing 0·006 μgm. of œstradiol-3 : 17β (low-dose group) and two had 0·01 ml. of Tyrode solution containing 0·06 μgm. of œstradiol-3 : 17β (high-dose group). The cultures were incubated at 37·5° C. for three or four days and examined daily.

From the second day onwards all explants showed a healthy outgrowth, usually of both epithelium and fibroblasts. Before incubation the explants showed a border of undifferentiated epithelium, two to three cells thick, on the inner or outer margins of the ring of tissue, but after twenty-four hours incubation the epithelium was usually visible on both inner and outer margins. At twenty-four hours it was still of the simple 'unstimulated' type in all explants. At 48 and 72 hr. the epithelium of the control group remained unchanged, but most of the explants treated with œstradiol showed thickening and some degree of stratification of the epithelium. In these, several layers of flattened cells appeared above the undifferentiated basal layer, and above them the most superficial layer of cells appeared swollen. Such changes are typical of the œstrogen-stimulated vaginal epithelium *in vivo*[3]. Thickening and stratification became more pronounced as the time of incubation increased, and at 72 and 96 hr. some explants had eight to twelve layers of flattened cells beneath a very swollen superficial layer. At 96 hr. some explants in the control group showed slight thickening in a few regions. Under polarized light the flattened cells of the stimulated epithelium showed strong birefringence in the plane parallel to the basement membrane, but the unstimulated epithelium was not birefringent.

Most cultures were kept for 96 hr. and were then fixed in Zenker with 5 per cent acetic acid, embedded in paraffin wax, sectioned serially and stained in Mayer's hæmalum, picric acid and eosin. Four of the control cultures were treated in this way. All were healthy and showed no evidence of stimulation. Five of the cultures treated with the low dose of œstradiol-3 : 17β were examined. Keratinization was observed in three of the cultures, and stratification and



Sections of explants of mouse vagina from 6-day old litter-mates. × 660.

(1) 96 hr. in control medium; ¶ unstimulated epithelium.

(2) 96 hr. in medium containing 0·06 μgm. œstradiol-3 : 17β; stratified epithelium with keratinized cells beneath a superficial layer

possible keratinization were observed in the fourth. The fifth was unhealthy and showed no sign of stimulation other than the prominent layer of superficial cells. Four of the cultures which received the high dose of œstradiol-3 : 17β were also examined. All were healthy ; two were keratinized, one became stratified and possibly keratinized, and one failed to respond. The histological appearance of the epithelium in control and in treated explants, respectively, is shown in Figs. 1 and 2.

In more recent work, the above experiments have been repeated with some modifications of technique, with œstrone, œstriol, œstriol glucuronide, œstradiol-3 : 17β, equilin and diethylstilbœstrol. Similar results have been obtained ; a full description will be given elsewhere.

The results reported above indicate that œstrogens are capable of producing vaginal cornification *in vitro*. This finding is important in discussions of the mode of action of these hormones. By means of the double-vaginal pouch technique, Robson and Adler[4] and Emmens[5] showed that the intravaginal action of true œstrogens is purely local. Our results directly corroborate these earlier findings and render untenable the recent thesis of Szego and Roberts[6] that œstrogens have to be 'activated' by the liver before they are capable of exerting their action.

Hechter, Lev and Soskin[7] believe that the development of hyperæmia is essential for cornification of the vagina. Our results do not support this view, but suggest that the œstrogens act primarily on the responding cells.

MARGARET H. HARDY

Division of Animal Health and Production,
Commonwealth Scientific and
Industrial Research Organization,
McMaster Animal Health Laboratory,
Sydney, N.S.W.

J. D. BIGGERS
P. J. CLARINGBOLD
Department of Veterinary Physiology,
University of Sydney,
Sydney, N.S.W.
Oct. 16.

[1] Gallard, P. J., "Hormones Regulating Growth and Differentiation in Embryonic Explants" (Hermann, Paris, 1942).
[2] Emmens, C. W., and Ludford, R. J., *Nature*, **145**, 746 (1940).
[3] Biggers, J. D., *J. Anat., Lond.*, **87**, Part 4, 327 (1953).
[4] Robson, J. M., and Adler, J., *Nature*, **146**, 60 (1940).
[5] Emmens, C. W., *J. Endocrinol.*, **3**, 174 (1942).
[6] Szego, C. M., and Roberts, S., "Recent Progress in Hormone Research", **8**, 419 (1953).
[7] Hechter, O., Lev, M., and Soskin, S., *Endocrinol.*, **26**, 73 (1940).

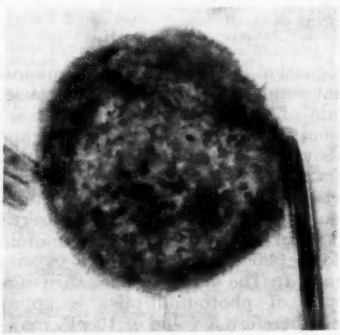
Acetocarmine as a Nuclear Stain in Rhodophyceae

In recent years, the earlier acetocarmine technique of Belling has been modified by Godward[1] and also Cave and Pocock[2] for use in staining the nuclei of various Conjugales and Volvocales respectively. So far as is known, the technique has not been applied previously to the Rhodophyceae, and at the suggestion of Dr. K. M. Drew, therefore, an attempt has been made to stain some members of this group by this method.

Of those available for use, the following have stained successfully : *Porphyridium cruentum* (Ag.) Naeg., *Porphyra umbilicalis* (L.) J. Ag., *P. umbilicalis* var. *laciniata* (Lightf.) Ag., *P. linearis* Grev., *Batrachospermum fruticulosum* Drew, *Antithamnion spirographidis* Schiffner, *Antithamnionella sarniensis* Lyle. and *Griffithsia setacea* C. Ag. (= *G. flosculosa* Batt.). However, *Polyides caprinus* (Gunn.) Papenf., *Furcellaria fastigiata* Lamour. and *Dumontia incrassata* Lamour. have not stained satisfactorily, and this may be due to the thick mucilaginous cell walls and large amount of floridean starch that surrounds the nucleus in some of the cells of these species.

The method which has been employed is a modification of those previously tried and is as follows : (1) Fix material in 3 : 1 absolute alcohol–acetic acid for ten minutes to a few hours. Best results are obtained when the material is stained soon after fixation. (2) Bring material down to water through 90, 70, 50 and 30 per cent alcohols. (3) Wash (two or three changes) with distilled water. (4) Mordant in freshly prepared 4 per cent iron–alum for 5–20 minutes. (5) Wash (two or three changes) with distilled water. (6) Place material on slide and add acetocarmine ; cover, and heat to boil (repeat boiling twice or thrice). (7) If material requires spreading, squash with cloth-covered finger. (8) Add fresh acetocarmine to margin of cover-glass, heat again and keep slide warm for ten minutes on hot plate. (9) Make permanent according to (McClintock's) method recommended by Manton[3]. (Temporary preparations invariably look more elegant than permanent ones.)

As the method is a rapid one, it has been found very useful in determining times of nuclear divisions, for example, in tetrasporangia and germinating tetraspores. In illustration of the results, a photograph of the first mitotic division in a germinating tetraspore of *Antithamnion spirographidis* Schiffner is reproduced herewith.



Prophase of first mitotic division in germinating tetraspore of *Antithamnion spirographidis* Schiff. Permanent acetocarmine. (× 1,000)

I wish to express my thanks to the authorities of Banaras Hindu University for awarding me a Holkar Fellowship enabling me to study in Manchester, and to Mr. E. Ashby for the photograph.

C. S. PRAKASA RAO

Department of Cryptogamic Botany,
University, Manchester.
Oct. 28.

[1] Godward, M. B. E., *Nature*, **161**, 203 (1948) ; *Ann. Bot.*, N.S., **14**, 39 (1950).
[2] Cave, M. S., and Pocock, M. A., *Stain Tech.*, **26**, 173 (1951).
[3] Manton, I., "Problems of Cytology and Evolution in the Pteridophyta", 296 (Cambridge, 1950).

Detection and Recording of Optical Transients by Photo-multipliers

The use of photo-multipliers for the detection and recording of optical transients is well known in the fields of gaseous discharge and of scintillation counting. In both these fields, involving time-intervals short compared with a microsecond, the limit of detection of the system is set by the shot noise associated with the photo-current and not by the thermionic emission from the cathode. The thermionic emission from the cathode of a photo-multiplier is usually quoted as about 10^{-15} amp./cm.^{2} or approximately 10^{-14} amp. for the whole cathode. This corresponds to an average rate of emission of electrons of approximately one electron in ten micro-seconds, and the probability of emission of an electron during any interval of time short compared with a microsecond is small.

The shot noise associated with a photo-current I_0 is given by :

$$(i_n)_{\text{rms}} = (2eI_0.\delta f)^{1/2}, \quad (1)$$

where δf is the bandwidth of the system and e is the electronic charge.

If we take the limit of detection to be :

$$(i_n)_{\text{rms}} = I_0, \quad (2)$$

then

$$I_0 = 2e.\delta f. \quad (3)$$

If the output current of the photo-multiplier, gI_0, where g is the gain, is being used to produce a voltage across an anode resistor R in parallel with the anode and stray capacitance C, then we may write approximately

$$\delta f = 1/2\,CR, \quad (4)$$

and therefore

$$I = ge/CR, \quad (5)$$

where I is the output current of the photo-multiplier.

The output voltage generated across the anode resistor R is :

$$V = RI = ge/C. \quad (6)$$

From equation (6) we see that this minimum value of V is independent of the value of R, varies directly as the gain of the photo-multiplier and is inversely proportional to the capacitance C. In the applications quoted above, the amount of light available is usually not much greater than the minimum amount that can be detected, and a certain amount of amplification of the resulting signals is needed. By inserting values of g and C in equation (6), the minimum voltage which the amplifier will be required to amplify may be determined. The output capacitance of an *R.C.A.* 931-*A* type of photo-multiplier is approximately 5 pF., and therefore a value of 10 pF. may be taken for C. The maximum gain obtainable from such a photo-multiplier is around 10^6, and therefore the minimum value of V for detection will be 0·016 volt.

From equation (5) we see that the minimum photo-current for detection corresponds to the release of one photo-electron in a time of CR. Since the efficiency of the photo-cathode of the 931-*A* type of photo-multiplier is such that approximately ten incident quanta are required to release one photo-electron, the minimum detectable light flux will correspond to the incidence of approximately ten quanta on to the cathode in a time of CR.

The above analysis of the minimum detectable signals neglects the contribution of the secondary emission to the noise-level observed at the anode of the photo-multiplier, as this has been shown to be small. It also assumes that the thermal agitation noise in the resistor R produces a noise voltage which is small compared with the amplified shot noise gI_0. The thermal agitation noise in a resistor is given by

$$(v_n)_{\text{rms}} = (4kTR\,\delta f)^{1/2}. \quad (7)$$

Substituting for δf from equation (4), we have :

$$(v_n)_{\text{rms}} = (2kT/C)^{1/2}. \quad (8)$$

In the limit, when the noise due to the resistor is equal to the amplified shot noise,

$$g = (2kTC/e^2)^{1/2}. \quad (9)$$

The above value of g represents the minimum gain which may be used to ensure that the noise across the resistor R is not the limiting factor in the detection of small values of light flux. It will be seen that this minimum value of gain is independent of the value of R but depends on the value of C. For a value of C of 10 pF., $g_{\min}$ is 2,500.

The above analysis has been based on the detection of a light flux, and a similar analysis may be performed where the object is the measurement of a light flux to an accuracy of one part in N. To attain this accuracy, the minimum number of photo-electrons which must leave the photo-cathode in the minimum resolution time τ is N^2 and therefore the minimum output current is :

$$I_{\min} = N^2\,ge/\tau. \quad (10)$$

Tables 1 and 2 show the minimum output currents required to maintain accuracies of 10 and 1 per cent respectively.

Table 1. Minimum Output Currents for Accuracies of 10 Per Cent

Gain	Resolution time		
	10^{-9} sec.	10^{-8} sec.	10^{-7} sec.
10^4	160 μamp.	16 μamp.	1·6 μamp.
10^5	1·6 m.amp.	160 μamp.	16 μamp.
10^6	16 m.amp.	1·6 m.amp.	160 μamp.
10^7	160 m.amp.	16 m.amp.	1·6 m.amp.
10^8	1·6 amp.	160 m.amp.	16 m.amp.

Table 2. Minimum Output Currents for Accuracies of 1 Per Cent

Gain	Resolution time		
	10^{-9} sec.	10^{-8} sec.	10^{-7} sec.
10^4	16 m.amp.	1·6 m.amp.	160 μamp.
10^5	160 m.amp.	16 m.amp.	1·6 m.amp.
10^6	1·6 amp.	160 m.amp.	16 m.amp.
10^7	16 amp.	1·6 amp.	160 m.amp.
10^8	160 amp.	16 amp.	1·6 amp.

The use of the *R.C.A.* 931-*A* type of photo-multiplier enables currents of up to about 80 m.amp. to be obtained with a resolution time of around $\frac{1}{4} \times 10^{-8}$ sec., and therefore the maximum gain which may be used to obtain an accuracy of 1 per cent is approximately 10^5. A gain of 10^7 lowers the accuracy which can be obtained to 10 per cent.

The above analysis shows that it is as important to endeavour to increase the maximum linear current which can be drawn from a photo-multiplier as to endeavour to increase the maximum gain which can be obtained.

I acknowledge the grant of an I.C.I. Research Fellowship which made this work possible.

R. F. Saxe

Department of Electrical Engineering,
Queen Mary College,
University of London.

Aug. 12.

FORTHCOMING EVENTS

Tuesday, December 29

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 3 p.m.—Mr. J. A. Ratcliffe, F.R.S.: "The Uses of Radio Waves". (Christmas Lectures adapted to a Juvenile Auditory.) (Further Lectures on December 31, January 2, 5, 7 and 9.)

Tuesday, December 29—Friday, January 1

SCIENCE MASTERS' ASSOCIATION (at Oxford).—Annual Meeting.

Tuesday, December 29

At 8 p.m. (in the Hall of Rhodes House, South Parks Road, Oxford).—Sir Cyril Hinshelwood, F.R.S.: "Thoughts on the Evolution of a Scientific Problem" (Presidential Address).

Wednesday, December 30—Saturday, January 2

GEOGRAPHICAL ASSOCIATION (at the London School of Economics, Houghton Street, Aldwych, London, W.C.2)—Annual Conference.

Friday, January 1

BRITISH PHYCOLOGICAL SOCIETY (in the Department of Botany, University College of London, Gower Street, London, W.C.1), at 10.30 a.m.—Symposium on "Algal Physiology and Biochemistry. Speakers: Dr. G. E. Fogg, Dr. L. Fowden, Mr. M. R. Droop, Dr. C. P. Spencer and Mr. F. J. Taylor. 4 p.m.—Second Annual General Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

PHYSICAL CHEMIST or ORGANIC CHEMIST (with physical leanings), for research into fundamental aspects of the oxidation of carbon—The Clerk, Birkbeck College, Malet Street, London, W.C.1 (January 2).

PHYSICIST (with a university degree in science and at least three years experience as a physicist in a radiotherapy unit) in the Department of Health, Southern Rhodesia Government—The Secretary, Southern Rhodesia Government, Rhodesia House, 429 Strand, London, W.C.2 (January 15).

PROFESSOR OF AGRICULTURAL BOTANY and a PROFESSOR OF MATHEMATICS—The Registrar, The University, Reading (January 25).

CHAIR OF BOTANY in the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (January 31).

PROFESSOR OF AGRICULTURE in the University of Adelaide, and HEAD OF THE DEPARTMENT OF AGRONOMY in the WAITE AGRICULTURAL RESEARCH INSTITUTE of the University—The Registrar, University of Adelaide, Adelaide, South Australia (January 31).

SENIOR LECTURER IN ANIMAL HUSBANDRY at the New England University College, Armidale, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Armidale, February 1).

ASSISTANT DIRECTOR to take charge of a team of chemists, physical chemists, physicists and mathematicians engaged on a comprehensive scientific study of the physical and chemical properties of rayon and synthetic fibres and problems associated with the application of these fibres—The Secretary, British Rayon Research Association, Barton Dock Road, Urmston, Manchester.

BIOCHEMIST (senior grade) to the Rochdale Group of Hospitals—The Group Secretary, Birch Hill Hospital, Rochdale, Lancs.

CHAIR OF GEOGRAPHY—The Secretary and Registrar, The University, Southamptou.

ENGINEER, PHYSICIST or MATHEMATICIAN (with first- or second-class honours degree in an appropriate subject, with at least three years relevant postgraduate experience) in the Ministry of Supply, Research Branch, Tolworth, Surbiton, to work on design and development of wide range of survey, photographic and printing equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.194/53A.

GRADUATE ASSISTANT (with degree in physics and/or mathematics, and an interest in scientific publication) for work in editorial department which will include preparation of mathematical and physical material for publication, and supervision of small scientific library—The Secretary-Editor, The Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

HONOURS PHYSICIST for research on the friction and lubrication of textile materials—The Director, Shirley Institute, Manchester 20.

LECTURER (with experience of rubber or similar high polymers and knowledge of electronics) IN PHYSICS—The Clerk, National College of Rubber Technology, Northern Polytechnic, Holloway, London, N.7.

LECTURER (with good honours degree in physics or equivalent qualification, and with suitable teaching, industrial or research experience) IN PHYSICS, at the College of Technology and Commerce, Cardiff—The Director of Education, City Hall, Cardiff.

METALLURGIST (qualified) to lead research team on the weldability of alloy steels—The Secretary, British Welding Research Association, 29 Park Crescent, London, W.1.

PHYSICIST (with first- or second-class honours degree in science, and preferably with five years experience as a hospital physicist) in the Medical Department of Hong Kong, for duties in the Radiotherapy Sub-Departments, working in collaboration with the Radiologist in technical aspects of radiotherapy and maintenance and care of specialized plant and equipment—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.117/51/013.

PHYSICIST (with practical experience of radiation physics and electronics)—St. Anne's City Hospital for Diseases of the Skin and Cancer, Northbrook Road, Dublin.

RESEARCH CHEMIST (with at least a good honours degree in chemistry, with appropriate subsidiary subjects) to undertake fundamental research on products of a natural origin—The Chief Research Chemist, Forestal Central Laboratory, Harpenden Rise, Harpenden.

SENIOR LECTURER (with a good honours degree, with industrial and research experience) IN THE HEAT ENGINES SECTION of the Department of Civil and Mechanical Engineering—The Secretary, The Royal Technical College, Glasgow.

SURVEY ENTOMOLOGIST (with good degree in entomology) in the East African Tsetse and Trypanosomiasis Research and Reclamation Organization, for work in connexion with tsetse surveys in Kenya, Uganda and Tanganyika—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.77/88/04.

TECHNICAL LIBRARIAN (with a knowledge of telecommunications, electrical engineering or physics, and technical library experience)—The Director of Research, British Telecommunications Research, Ltd., Taplow Court, Bucks.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The Webster Plass Collection of African Art. (The Catalogue of a Memorial Exhibition held in the King Edward VII Galleries of the British Museum, 1953.) By William Fagg. Pp. 47+46 plates. (London: British Museum, 1953.) [411

Ministry of Fuel and Power: Safety in Mines Research Establishment. Thirty-First Annual Report on Safety in Mines Research, 1952. Pp. 76+4 plates. (London: H.M. Stationery Office, 1953.) 3*s*. net. [411

National Advisory Committee on the Employment of Older Men and Women. First Report. Pp. 62. (Cmd. 8963.) (London: H.M. Stationery Office, 1953.) 2*s*. net. [411

Report on the Work of the British Council for the Year ended 31st March 1953. Pp. v+105. (London: British Council, 1953.) 2*s*. 6*d*. [411

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Proceedings of the University of Durham Philosophical Society. Vol. 11, No. 6: Observations on the Flora of the Isle of Lewis, Isle of Harris and the Shiant Isles in 1952. By Dr. J. W. Heslop Harrison. Pp. 83–90. Vol. 11, No. 7: The Tholeiite Dyke at Cowgate, Newcastle-upon-Tyne; The Carboniferous Igneous Rocks of the Kelso District. By Dr. S. I. Tomkieff. Pp. 91–102+1 plate. Vol. 11, No. 8: Notes on the Birds of Lake Elmenteita, Kenya Colony. By M. W. Ridley and Lord R. C. Percy. Pp. 103–118+4 plates. (Durham: University of Durham Philosophical Society, 1953.) [411

Philosophical Transactions of the Royal Society of London. Series A. Mathematical and Physical Sciences. No. 910, Vol. 246 (29 October 1953): Finite Plane Strain. By J. E. Adkins, A. E. Gree, and R. T. Shield. Pp. 181–213. 7*s*. 6*d*. No. 911, Vol. 246 (5 November 1953): Wave Functions of the Hydrogen Molecular Ion. By D. R. Bates, Kathleen Ledsham and A. L. Stewaer. Pp. 215–240. 6*s*. No. 912, Vol. 246 (5 November 1953): Theoretical Studies in Nuclear Structure. IV. Wave Functions for the Nuclear p-Shell. Part B. $(p^n/p^{n-z}p^z)$ Fractional Parentage Coefficients. By J. P. Elliott, J. Hope and H. A. Jahn. Pp. 241–279. 9*s*. Series B. Biological Sciences. No. 648, Vol. 237 (4 November 1953): Form and Habit in *Pinna Carnea* Gmelin. By Prof. C. M. Yonge, F.R.S. Pp. 335–374. (London: Cambridge University Press, 1953.) [411

Annual Report of the Director of the Meteorological Office for the Year April 1, 1952 to March 31, 1953. Pp. 56. (M.O. 573.) (London: H.M. Stationery Office, 1953.) 2*s*. net. [611

Nimonic Alloys in Aircraft Gas Turbines. Pp. 12. (Birmingham: Henry Wiggin and Company, 1953.) [611

International Society of Soil Science. Joint Meeting of Commission II (Soil Chemistry) and Commission IV (Soil Fertility and Plant Nutrition), Dublin, July, 1952. Transactions. Vol. 1: Pp. 335. Vol. 2: Pp. 404. (Dublin: Department of Agriculture, 1953.) 2 volumes 120*s*.

Discussions of the Faraday Society. No. 13, 1953: The Physical Chemistry of Proteins. Pp. 288+4 plates. 35*s*. net. No. 14, 1953: The Reactivity of Free Radicals. Pp. 256+3 plates. 35*s*. net. (London: The Faraday Society, 1953.) [911

Department of Scientific and Industrial Research. Forest Products Research Bulletin No. 26: An Atlas of End-Grain Photomicrographs for the Identification of Hardwoods. Pp. iv+87. (London: H.M. Stationery Office, 1953.) 12*s*. 6*d*. net. [1111

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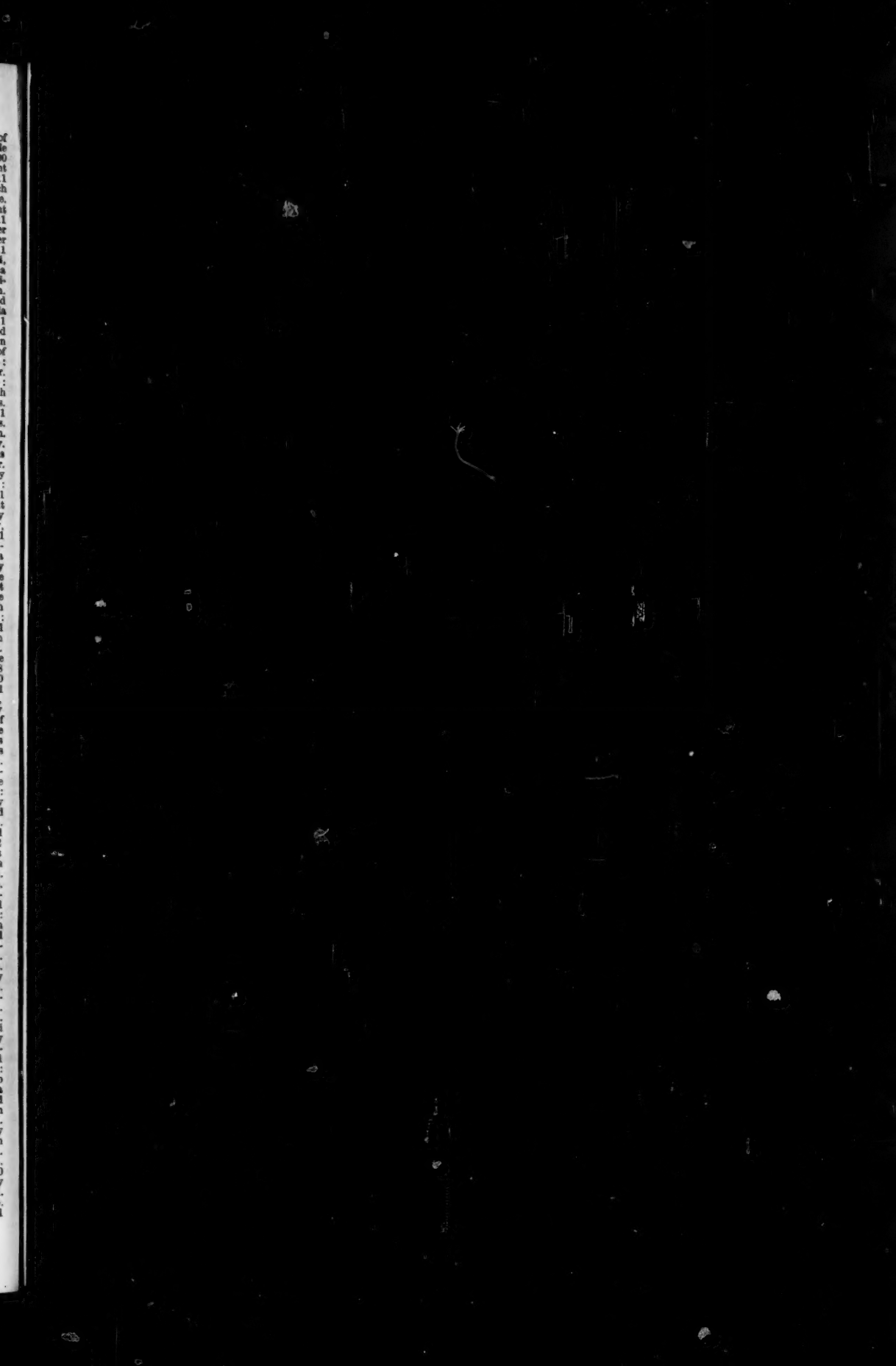
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